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Springfield's Generating System

PARALLEL OPERATION OF STEAM AND WATER DRIVEN POWER PLANTS OF THE UNITED ELECTRIC LIGHT CO.; PROVISION FOR CONTINUITY OF SERVICE

ELECTRIC ENERGY FOR light and power is supplied the people of Springfield, Mass., and vicinity, from a generating system composed of 4 power stations, 3 of which are water power plants, while the fourth is entirely steam driven. Only 3 of these, however, may be rightfully said to belong to the Springfield system, the other referred to being the Turners Falls hydroelectric development, the high-tension transmission lines of which connect this system for the purpose of interchange of energy between Turners Falls and Springfield.

The steam-driven plant, the largest of the 3, is located at the foot of State St., in Springfield, while the 2 hydroelectric stations are at Indian Orchard and Bercham Bend, approximately 10 and 8 mi. respectively from the Springfield plant. Station 3, or the Bercham Bend plant, is about 2 mi. beyond the Indian Orchard development, or Station 2, both of which derive their energy from the waters of the Chicopee River.

Electrically, these 3 stations are interconnected by double sets of 2-phase, 5500-v. transmission lines, the entire system forming a closed triangle having sides 10, 8 and 2 mi. respectively. Under normal operating conditions the water-power plants supply all the energy they are capable of developing, while the Springfield steam station cares for variations in the load. Should, however, either one or both of the water-power plants become inoperative, due to lack of water or other reason, the entire load may be carried by one or both of the

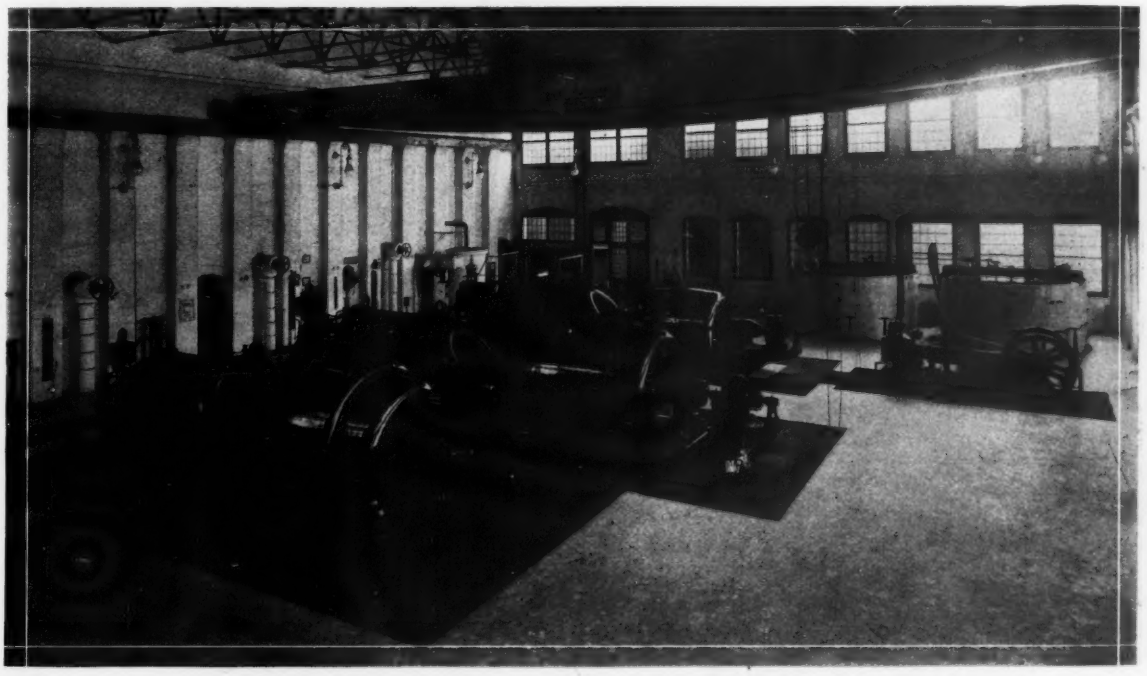


FIG. 1. INTERIOR OF NEW TURBINE ROOM, SPRINGFIELD STATION

remaining stations. Or, should transmission line trouble arise, the entire system may, with the scheme of interconnection employed, continue in operation, an ingenious switching arrangement in each station allowing a ready means for transmitting over any line desired.

Springfield Station

This plant, which originally contained belted generating units, is the result of building and equipment alterations and additions, and is a striking example of steam-power plant development. Due to these changes and gradual growth of the plant following the introduction of more modern and efficient generating machinery and control apparatus, accompanied by a natural growth of load, there are at the present time 2 boiler rooms and 2 engine rooms, separate buildings, but all joined so as to constitute a single unit.

Steam Generating Equipment

As just stated, this is housed in 2 separate buildings, one of which is known as the old boiler room, the other as the new. The main equipment of the 2 is practically alike and consists of porcupine boilers provided with dutch ovens and Murphy stokers. In the old boiler room are 8 400-hp. units set in 2 rows and in 2 batteries of 4 boilers each, with a firing aisle between, while the new boiler room contains 16 400-hp. units installed in a similar manner. When in operation, these boilers are normally worked at 150 per cent of their rated capacity under a gage pressure of 150 lb. and deliver steam superheated to from 30 to 40 deg. F.

The boilers in the old boiler room are as a rule used during the winter months only, although they can be fired up at any time, if necessary.

If necessary, however, in case of trouble or to tide over peak loads, the boilers may, and are, at such times forced to carry loads 300 per cent of their rated capacity, made possible, according to those in charge, by the use of McClave blowers with which these steam generators are equipped.

All boilers are equipped with Ellison draft gages and Squires feed water regulators, and several are also provided with steam flow meters.

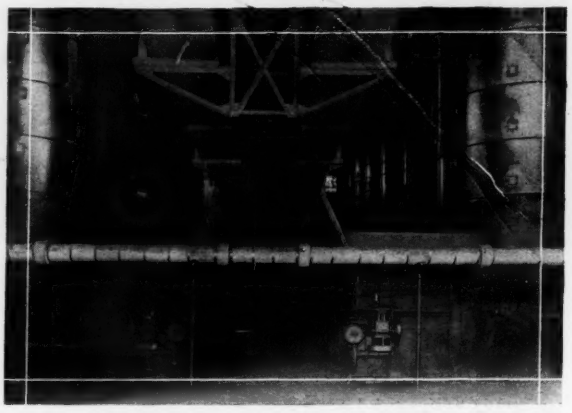


FIG. 3. LOOKING DOWN FIRING AISLE OF BOILER ROOM

In the old boiler room each boiler is connected to the 12-in. steam main by a 5-in. lead, while those in the new section are connected by means of 6-in. leads, with long radius bends to a 16-in. header.

Coal is delivered in cars run over either one of 2 concrete receiving pits into which it is dumped. The

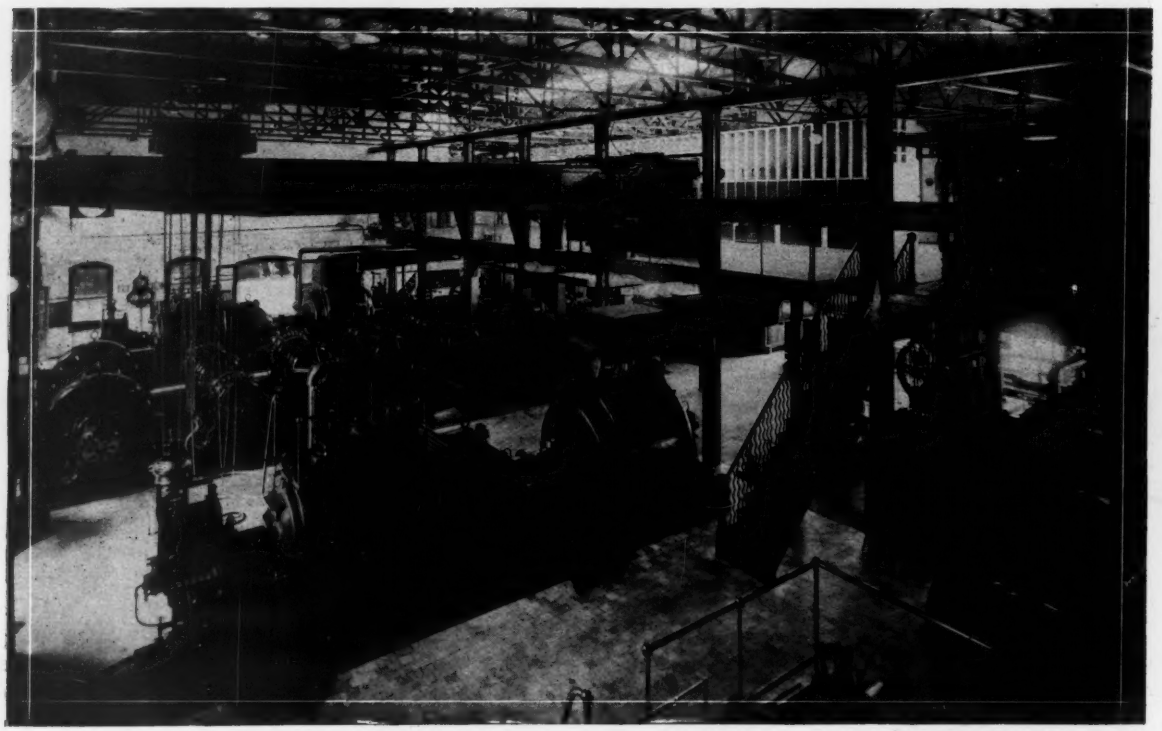


FIG. 2. INTERIOR OF OLD TURBINE ROOM, SPRINGFIELD STATION

smaller of these pits is provided with a ¾-ton Sprague overhead electrically-operated crane and grab bucket, by means of which the coal is raised and transferred to a concrete hopper, whence it passes into a Robbins crusher. It is then elevated by a belt elevator to scales, weighed and delivered to the stoker hoppers by a belt conveyor, a double discharging chute distributing it to the stokers. Coal dumped into the other or larger pit is picked up with a 5-ton, electrically-operated locomotive crane and delivered to the crusher hopper from which it follows the course outlined above.

FIG. 4. BUSBAR COMPARTMENTS AND GENERATOR SWITCHBOARD AT LEFT; DISTRIBUTION PANELS AND DIRECT-CURRENT SWITCHBOARD AT RIGHT

Below the boiler room floor are the ash pits and ash-handling equipment. Ashes are dumped from the pits into industrial cars in which they are carried to a receiving pit, there dumped, and by means of an elevator raised to an overhead receiving box to be transferred by a chute to trucks or wagons and hauled away.

Water Supply

All water for steam making, condensing and general house purposes is taken from the Connecticut River. That used as boiler feed is delivered to 2 Continental filters located in the new turbine room and having a capacity of 460 gal. of water a minute. Leaving the filters it is carried to a storage tank to be delivered as required to a National feed-water heater, and then to the boilers. Before entering the filters the water is treated with alum, the amount used being varied according to the condition of the feed supply.

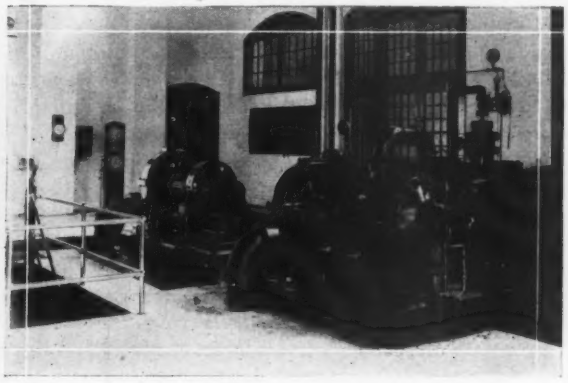


FIG. 5. TURBINE-DRIVEN GENERATOR AND CENTRIFUGAL PUMP

Turbine Rooms

In the old section, as shown in Fig. 2, are 3 1000-kv.a. Westinghouse turbo-alternators furnishing 2-phase, 60-cycle current, each unit receiving its excitation from exciters direct connected to Westinghouse standard automatic engines.

Jet condensers used in connection with these generating sets are located in the basement below, while their vacuum pumps are on the main floor.

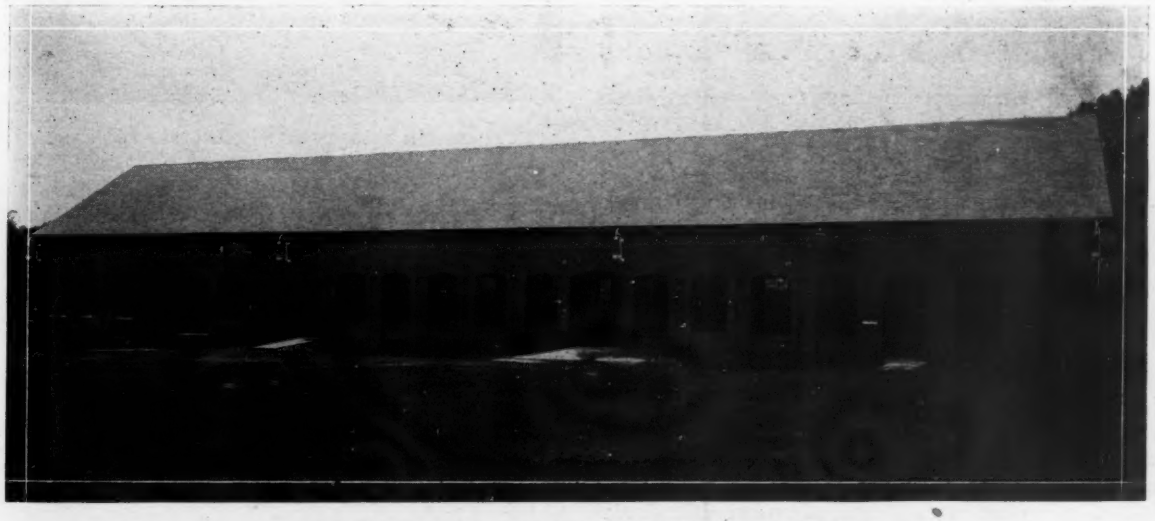


FIG. 6. EXTERIOR VIEW OF INDIAN ORCHARD STATION

Originally the generators of these sets were of the open casting type, but for the purpose of securing adequate ventilation have since been provided with air ducts leading from the top of the casing out through the side of the building.

In this part of the plant are also found 6 mercury arc rectifiers and 18 Brush arc lighting machines used to supply current to the street lighting system. The latter are driven by alternating-current induction mo-

tors, each motor being directly coupled to the shafts of 2 arc machines by flexible couplings.

To supply the existing demand for 110-v., direct-current there is installed a 40-kw. motor-generator set which may be and, in times of emergency, is used for excitation purposes.

Two 500-kw. rotary converters, located at the State St. side of the building between the arc machines and the arc plug switchboard, supply current to 500-v. power circuits.

New Turbine Room

Adjacent to the old turbine room and built as a continuation thereof is the new turbine room which houses 3 5500-v., 2-phase, 60-cycle Westinghouse-Parsons turbines rated at 2500, 4000 and 5000 kv.a. respectively. Each of these is a condensing unit with the condensers, as in the old section, located below. Excitation for these sets is obtained from independent exciters directly connected to the generators.

This room also contains the 2 feed-water filters previously referred to, a dry air pump, 2 boiler feed pumps

FIG. 7. TWO-PHASE BELTED GENERATOR, WATER WHEEL GOVERNOR AND SWITCHBOARD, INDIAN ORCHARD STATION

and an auxiliary turbine-driven, direct-current, 50-kw., 125-v. generating set used for station lighting, although applicable for excitation purposes.

Along the boiler room wall are the steam gages, mercury columns, Venturi meter and feed-water heater.

Electrical Control

All switching and control equipment, except that for the arc lighting circuits is on a balcony at the river side of the old turbine room. This balcony, which is reached by the stairway shown in Fig. 4, contains the concrete bus structure, with disconnecting switches, high-tension bus bars and solenoid controlled oil switches, 6-panel generator switchboard, 24-panel distribution board, direct-current board for control of rotary converters and 600-v., direct-current circuits and a small storage battery for the operation of oil-switch solenoids and engine-room signals. Instead of being installed in a separate room, the cells of this battery are mounted on a framework of angle irons, at the front end of which is mounted a control panel.

All alternating-current generators feed into common busbars at a voltage of 5500 which, for local light and power distribution, is stepped down by transformers to 2300 v., the buses and switching equipment being in duplicate so that in spite of a breakdown of any of the station equipment the service will in no way become crippled.

To facilitate synchronizing the various generating units, a large double-faced and illuminated synchroscope in plain view of both turbine rooms and the switching balcony has been placed in the brick wall separating the old and the new turbine rooms.

For the Turners Falls tie-in service, 2 banks of 2 transformers each, changing from 2 to 3-phase and from 5500 to 66,000 v., are located in a separate transformer house. These banks may be used with either one of 2 sets of transmission lines, thus insuring positive service in case of breakdown.

Indian Orchard Development

Under an average head of 35 ft., the waters of the Chicopee River are diverted to a small forebay in front of a wooden structure used as a gate house, located about 200 ft. from the main building shown in Fig. 6.

FIG. 8. TRASH RACK, FORE BAY AND POWER PLANT AT BERCHAM BEND

Hand-operated gates control the flow of this water through 4 11-ft. penstocks leading to 4 36-in. double-flow McCormick water wheels in the basement of the station.

While one of the wheels is direct-connected to a 600-kv.a., 2-phase, 60-cycle, alternating-current generator, the 3 remaining units are belt driven and consist of 2 468 and 2 330-kv.a., 2-phase, 60-cycle alternators and one 500-kw., direct-current generator. One of the 468-kv.a., alternating-current machines and the single direct-current generator are driven from the same wheel by means of pulleys attached to the ends of the shaft of the turbine runner.

Alternating current is generated as at Springfield at a voltage of 5500; direct current is maintained at about 500 v.

For the supply of energy to local manufacturing companies at a voltage lower than that generated by the direct-current generator, a 300-kw. rotary converter is employed.

Excitation for these various units is obtained from individual exciters which in the case of the 468 and 600-kv.a. units are direct connected, while for the others belt drive is used.

One end of the building is given over to the alternating-current and direct-current switchboards, 2 mercury arc rectifiers used in conjunction with the local street lighting system and other auxiliary electrical equipment.

All outgoing transmission lines are protected by General Electric aluminum lightning arresters.

During cold weather, the building is heated by a 30-hp., low-pressure heating boiler located in the basement.

Bercham Bend Station

About 2 miles below the Indian Orchard plant and also along the Chicopee River is the Bercham Bend, or as it is more generally known among the operators, Station 3, which was but recently constructed for the purpose of developing the available 14-ft. head between Indian Orchard and this point.

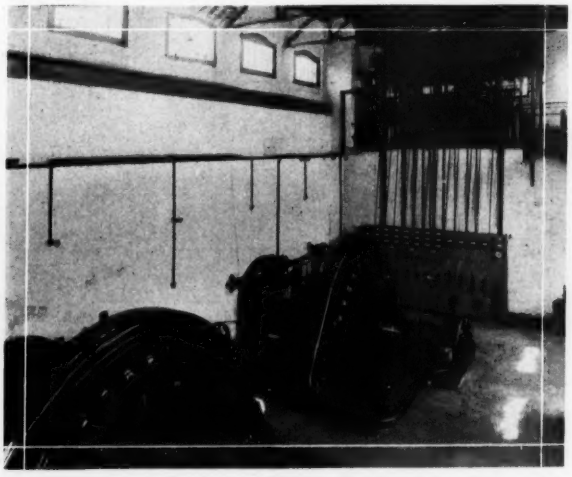


FIG. 9. GENERATORS, SWITCHBOARD AND REMOTE CONTROLLED SWITCHING APPARATUS ON BALCONY, BERCHAM BEND STATION

Surplus water not needed for the operation of the wheels is diverted over the spillway of a 241-ft. dam, while that utilized is carried to the forebay shown in Fig. 8. Six hand-operated head gates of approximately 6 by 3 ft., control the flow of this water.

The generating equipment of this station consists of 2 400-kv.a., 550-v., 2-phase, 60-cycle Westinghouse alternating-current generators, each machine being directly connected to and driven by 2 McCormick waterwheels rated at 150 hp. each. Direct-connected exciters furnish the necessary exciting current for the main generator.

Although the switchboard is placed on the floor of the generating room which is about 16 or 18 ft. below the ground level, all oil switches are placed on a balcony above, where also may be found transformers for the lighting service for East Springfield, single-phase voltage regulators and electrolytic lightning arresters. The oil switches on this balcony are operated from the board below through the medium of long rods shown in the background of Fig. 9.

To allow the current generated here to be fed into the transmission system, the alternators are designed and operated to give a voltage of 5500 in conformity with the other stations.

W. H. Damon, Superintendent of Generation of the United Electric Light Co., is in direct charge of this system of generating stations and courtesies extended by him in the preparation of this article are acknowledged.

Points on Rubber Belt Construction

BRIEFLY, the process of belt manufacture is as follows:

Cotton duck, of such weight and strength as is required for the work to be done, is frictioned or coated with rubber upon the calender. The quality of the rubber, like the weight and strength of the cotton, varies according to the nature of work to be done. The frictioned fabric is then cut into definite widths according to the width of the finished belt, after which the plies of fabric are built up either by folding or laying ply upon ply or a combination of both.

After the belt is built up and the cover applied, a seaming strip of high grade rubber is laid over the outside joint in order to weld this joint firmly together and prevent separation or opening up of the seam. The raw belt is then rolled upon a shell and given a slight cure

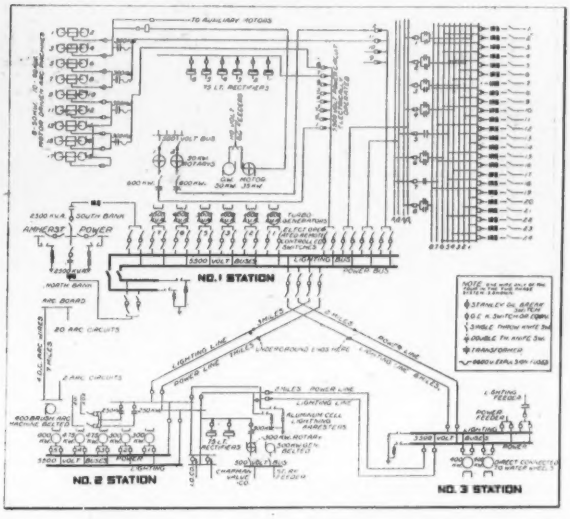


FIG. 10. GENERAL LAYOUT OF SPRINGFIELD'S GENERATING SYSTEM

in open heat in order to vulcanize the edges. After the "first cure" the belt is carefully vulcanized between the polished plates of a powerful hydraulic press. The rubber is forced into the duck, and the whole belt becomes perfectly smooth and firm. Just prior to vulcanizing, the belt is stretched under great pressure, thus minimizing stretch when the belt is put in actual use.

Rubber belts should be run at not less than 200 ft., nor over 5000 ft. a minute, a good average being 2000 ft.

Shifters should not be used as, once the edges of rubber belting are worn through, the plies readily separate.

All animal oils and greases are injurious to rubber belting.

Developments in Air-Lift Pumping

METHODS OF AIR SUPPLY; SUBMERGENCE AND LIFT; AIR REQUIRED; AIR LIFT "BOOSTING." BY S. W. SYMONS

AIR-LIFT PUMPING has come into use very largely during the past few years for municipal and industrial water supply and has given a very good account for itself when properly installed under favorable conditions.

It is the purpose of this article to illustrate and describe the most recent developments and devices used and to give an outline of its operating principle sufficiently complete to enable comparison to be made between it and other methods.

THEORY OF THE AIR LIFT

THE ORIGINAL theory of the air lift as outlined by Dr. Julius G. Phole in his patent specifications (Dec. 6, 1892), is, that when air is introduced into the lower end of an eduction pipe, whose upper end rises about

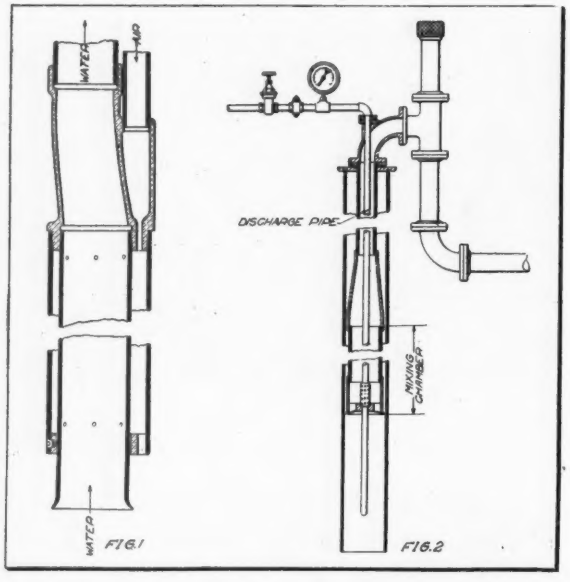


FIG. 1. ANNULAR TYPE OF MODERN AIR SUPPLY
FIG. 2. CENTRAL AIR PIPE SYSTEM WITH MIXING CHAMBER

the same distance above the water that its lower end is submerged, the compressed air will first expel the standing column of water and subsequently, by the continual inflowing of the compressed air under a pressure just sufficient to overcome the resistance of the water outside the eduction pipe, it will arrange itself in alternate layers, forming pistons of air in the pipe which force corresponding pistons of water upwards.

Up to a few years ago, air-lift pumps were designed to facilitate the formation of layers; but the theory of alternate layers of air and water has long since been exploded and replaced by the theory that, after the first discharge of water, the effect is to aerate and reduce the specific gravity of the water in the eduction pipe which is moved upwards by the buoyancy and expansion of the air bubbles, aided by the greater weight of the solid column of water surrounding the eduction pipe.

Contrary to the formerly accepted opinion, the formation of large bubbles of air was found to be detrimental to the working of the pump, as they tend to drive through the water without doing their share of useful work. The slip of the bubbles constitutes the chief loss of energy in the air lift, varying as the square root of the volume of the bubble.

Air-lift pumps are now designed to break the air up into fine streams, as shown in Figs. 1 and 2, which show 2 styles of modern pumps of the "Imperial" de-

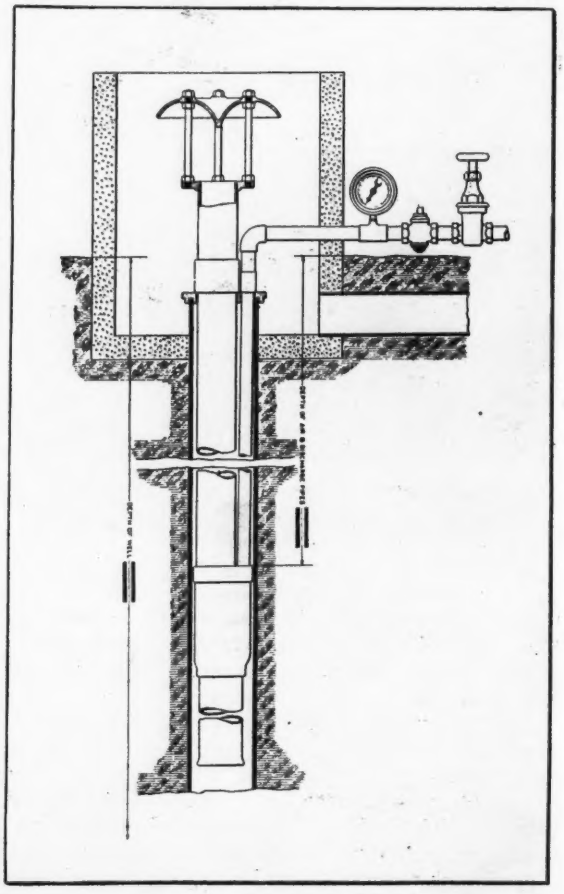


FIG. 3. DISCHARGE HEAD FOR DIRECT DISCHARGE TO BASIN

sign. Figure 1 shows the "annular" type. The pump proper is usually about 8 ft. long and is provided with several rows of holes some distance apart, which are uncovered successively when the pump is started up and remain more or less uncovered, according to the relative pressure and volume of the air and water. Provision is made to eliminate trouble from scale or dirt entering the air pipe by leaving the space between the inner and outer shell entirely unobstructed.

Figure 2 shows the central air pipe system which is used where a large quantity of water is to be handled from a strong well or where the diameter of a well will not permit of the side by side arrangement of discharge and air pipe. In this type the mixing chamber is considerably larger in diameter than the eduction pipe, so that the air and water are mixed at relatively low velocity and discharged at a higher velocity. The air pipe ends in a long trap to catch any scale or dirt that may be carried through the system.

An added refinement, which tends towards a higher efficiency, is the air discharge, from which the cool

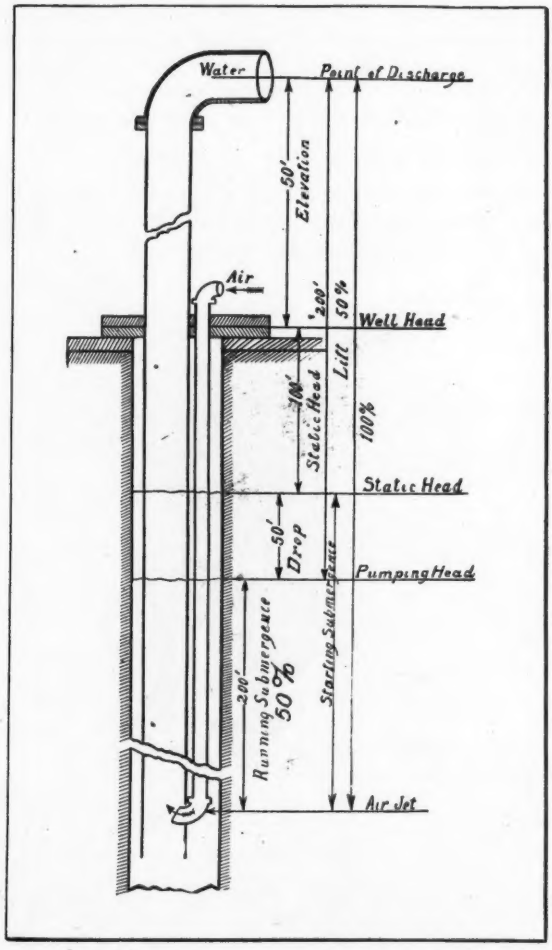


FIG. 4. ILLUSTRATION OF TERMS AND HEIGHTS IN AIR-LIFT INSTALLATION

air is generally piped back to the compressor. The illustration also shows clearly the method of piping the well when the water is to be discharged some distance away.

Figure 3 shows the most up-to-date arrangement of piping when the water is to be discharged directly into a concrete basin set over the well; this is a very common and highly efficient arrangement and one which should be used wherever possible.

Terms and Proportions

Although it is impossible to construct a formula which will cover all cases, the following data will enable any engineer to calculate the requirements for any given instance, if certain data covering the case are known.

Referring to Fig. 4: Static Head is the distance from the surface of the ground to the standing water level in the well when not pumping. Drop is the distance the water recedes when the well is delivering a certain quantity of water. Elevation is the distance above the ground surface to which it is desired to deliver the water. Lift consists of the static head plus the drop plus the elevation. Submergence is the depth that the air pipe is submerged below the level of the water in the well. There are 2 classes of submergence—starting submergence, which is temporary, and running submergence, which is the important factor in any pumping proposition. It is usually expressed in terms of the total length of the water column from the point where air is introduced to the point of discharge. Thus 50

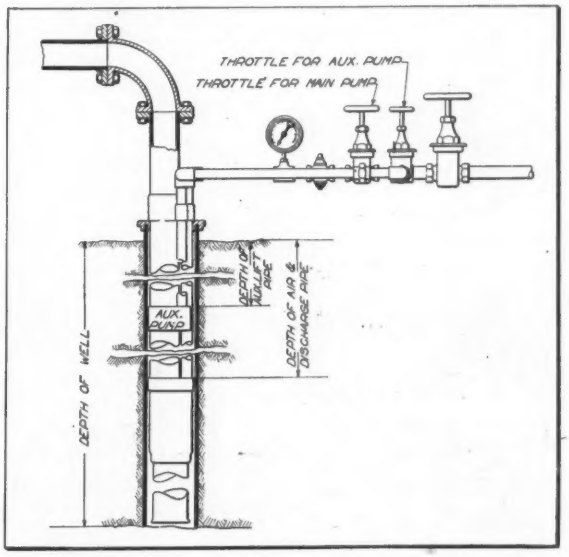


FIG. 5. SPECIAL AUXILIARY FOR LARGE "DROP"

per cent submergence means that the total lift, or head, and the running submergence are equal.

Necessary percentage of submergence varies in accordance with the lift; low lifts require proportionately more submergence than high lifts. As the lift increases the necessary submergence decreases. The range of these percentages is found within the following limitations: For a lift of 20 ft., 66 per cent; for a lift of 500 ft., 41 per cent.

When the total lift and running submergence are known, the following formula can be used to calculate the approximate amount of free air required and from this the compressor capacity can be figured after making due allowance for the usual losses.

$$V = L \div [\text{Log}\,(S + 34) \div 34) \times C]$$

Where V = Free air required to raise 1 gal. of water,

L = Total lift in feet,

S = Running submergence in feet,

C = Constant in table following.

TABLE FOR VALUE OF C WITH PROPER SUBMERGENCE

Lift in feet, (L)	Constant
10 ft. to 60 ft. inclusive	245
61 ft. to 200 ft. inclusive	233
201 ft. to 500 ft	216
501 ft. to 650 ft	185
651 ft. to 750 ft. inclusive	156

The necessary pressures can be calculated from the following:

Starting Pressure = (depth of pump or foot piece in well less than the static head or starting submergence) × 0.434.

Working pressure = (depth of pump, or foot piece, in well less the pumping head or running submergence) × 0.434 + friction in pipe + 2 lb. back pressure in pump.

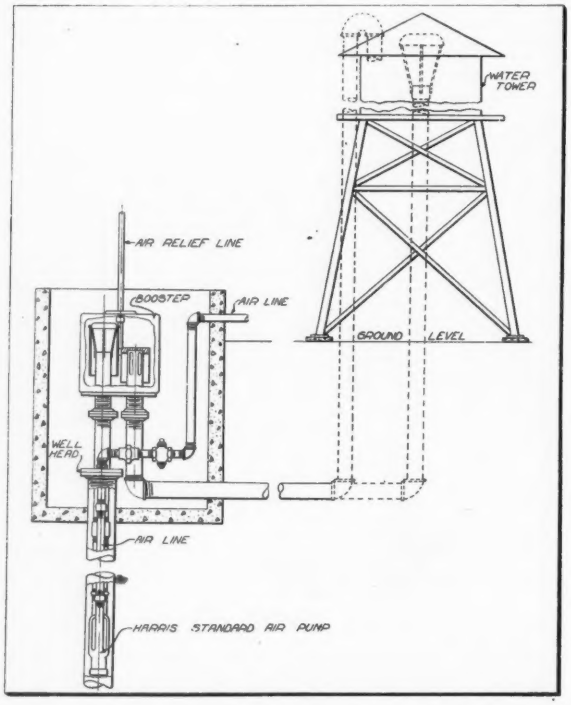


FIG. 6. ARRANGEMENT OF AIR-LIFT PUMP AND "BOOSTER"

Since the actual pumping level in a well is seldom known in advance of a test, it is customary to assume certain conditions of lift, quantity and submergence, as experience dictates, and design the air and water piping accordingly.

As the air pressure required with an air-lift pump depends upon the submergence, it follows that the starting pressure is higher than the running pressure. In some wells the difference between the static and pumping heads may be sufficiently great to make the starting pressure so much higher than the running pressure as seriously to overload the air compressor. These are known as wells with a large "drop." Air compressors are designed for maximum economy at the average air pressure which, in an air-lift pump, remains constant while the pump is in operation, the capacity for overload is limited and it is dangerous to exceed the limit.

In Fig. 5 is shown an arrangement known as the compound air lift which will overcome this difficulty. It consists of a standard air-lift pump with a special auxiliary or starting pump placed so that its submergence, with respect to the static head, will be such as to utilize the maximum pressure of which the compressor is capable without dangerous overload. When starting a well, the air is first turned into the auxiliary pump and, as the head lowers, the standard pump comes into action and the auxiliary pump is gradually turned off.

It is essential that both the air and water pipes be properly proportioned because the velocity of flow is an important factor, and it is here that experience plays a most important part. If too large a pipe is used, the air finds its way through the water without doing any work. If too small a pipe is used, there will be excessive friction and inefficient expansion of the air bubbles.

THE AIR-LIFT "BOOSTER"

IN THE operation of air-lift pumps the movement of water above the surface horizontally or at any angle, combined with subsequent lift has caused trouble, and unless the system has been carefully designed, the efficiency has been low, and it has also been considered necessary to submerge the air nozzle below the water level a distance bearing a large ratio to the actual total lift.

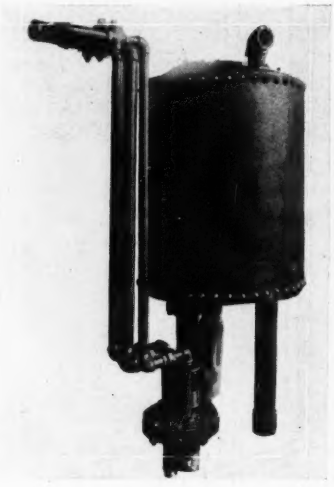


FIG. 7. "BOOSTER" ASSEMBLED

It is the object of a booster to force solid water horizontally or vertically through a pipe or pipes from an air-lift pump, the air being separated from the water in the booster, and its pressure utilized to force the water horizontally or to a higher level.

The work to be done by the booster, represented by the lift and friction head, should not exceed 25 per cent of the total working air pressure in the air-lift pump.

The diagram, Fig. 6, shows the arrangement of booster and pump, and Fig. 7 shows the booster alone. The booster is placed directly over the well, so that the air-lift pump discharges into it vertically. The mixture of air and water, as delivered by the air lift, separates in the booster and the pressure of

the air is utilized to do the work. The operation is simple. The amount of air within the booster is controlled by the water level. An automatic valve operates so that, as the water rises, the valve is closed and a pressure is built up in the booster, and vice-versa, as the water falls, the valve opens to allow the air to escape from the booster. This air either passes to the atmosphere or to the intake side of the compressor, as may be desired. In returning the air to the compressor, care should be taken to separate as much moisture as possible from the air before it is taken into the compressor.

The most important advantage of the booster is the delivery of the water at the desired point without the extra expense of additional pumping equipment.

The air required for operation of pump and booster is found by adding the elevation above ground (work done by booster) to the total lift in the well, and then using the regular formulas. The horizontal run is not taken into account except that any friction in the pipe line should be added to the total lift. The friction should be kept as low as possible, even if necessary to increase the diameter of the flow line from the booster over that of the standard size outlets.

Efficient Operation of Boiler Rooms

TEXTILE MILL PLANT SHOWS HIGH ECONOMY WITH ORDINARY EQUIPMENT

"OUR factory is not an immense affair like some of our competitors in the textile business have," the chief engineer was explaining to me as we walked through the mill from the general office to the engine room, "but you will notice that our machines run regularly without much fluctuation in load during the working hours of the day."

Stepping into the engine room, the regular clock-like click of the Corliss engine and the rhythmic whirl of a big belt gave emphasis to the chief's statement of steady load.

"A number of years ago," he went on, "we were compelled either to make great improvements in our plant or buy current from outside. After due consideration we installed this plant. It is not large and as finances were none too plentiful we have done without many things which would help to reduce our expenses and show us what kind of work we are doing, but even at that we are better off by several thousand dollars a year than if we were buying our power from outside."

To prove his statement, I was shown cost and operating records for a few years back. These were of more than ordinary interest for they showed not only a low cost of power for the size of plant, but a gradual decrease, clearly indicating that a careful study of conditions was being made and errors righted.

"One of the faults of the installation," the chief pointed out as an example, "was the heating system, the factory being heated by hot water which was taken from the economizer, but this arrangement has been changed, a live steam heater being employed at the present time, which accounts for this drop in expenses," pointing to an item in his records.

In the boiler room are 5 Dillon-Manning boilers of standard construction, each having a rating of 250 hp. based on 10 sq. ft. heating surface to a horsepower, but at times are operated as high as 200 per cent rating. The steam pressure carried is 175 lb. and the superheating surface in the boiler gives about 40 deg. of superheat. The flues are 2½ in. in diameter and 17 ft. long.

The grate is 7 ft. in diameter and of the shaking type with an air space of 25 per cent. This gives 65 sq. ft. of heating surface per square foot of grate area. The distance from the grate to tube sheet is 5 ft., but the engineer considers this too small for the coal he is using. The fire sheet in these boilers is made in 3 pieces which has given some trouble due to cracks developing around the firing door to the first joint on either side. Later types of these boilers have the fire sheet electrically welded into one piece which overcomes the above trouble.

Safety water columns with high and low alarms are attached to the side of the boilers in the usual way prescribed by the Massachusetts rules. The water level is ordinarily carried at 1½ to 2 gages and the columns are blown down the first thing every morning. One of the great savings in this plant is the absence of a feed pump as ordinarily used. The city water pressure is sufficient to feed the boilers but some friction is encountered in the economizer which necessitates the use of a booster pump.

A fusible plug is placed in one of the tubes which is made extra thick for that purpose, and access to the plug is had through a handhole.

The feed line discharge is about ¼ way up on the tubes, the inside arrangement being perforated pipe extending nearly to the opposite side of the shell.

The blowoff pipe is connected to the bottom of the water leg at the back and has 1 angle blowoff valve; all boilers blow into one pipe leading to outside drain. Blowing down is done at midnight when the boilers are banked and the water is lowered from the third to the first gage.

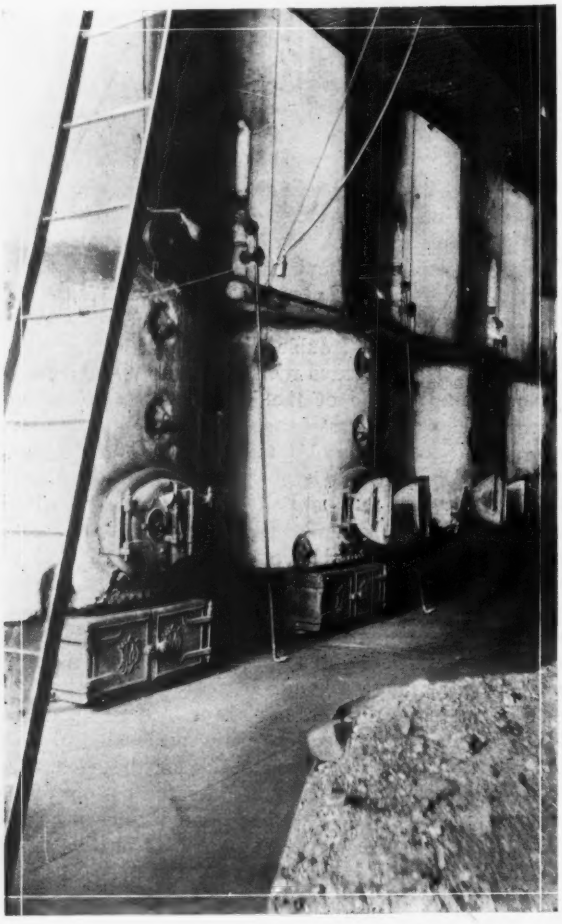
Two 4-in. safety valves are placed on the steam outlet from each boiler. These are set to blow at 180 lb. and blow back 3 to 5 lb. They are opened once a day to be sure they do not stick. The manholes and handholes are standard size and location for the Dillon-Manning boiler. There are no steam baffles, dry pipe nor dome, but the heating surface above the water line gives 40 deg. of superheat to the steam.

FIRING METHOD

FIRING is done on the alternate plan, the instructions given being to smooth the fire with a light rake before firing, then fire on one side. This, it is claimed, cuts down the clinkers and covers the holes that may have developed. The thickness of the fuel bed is carried at 7 in., and strict, definite rules as to the number of shovelfuls of coal and the intervals of firing are given

the fireman when he first comes on the job, but as he becomes familiar with the operation of the boilers he is left to his own judgment in regard to details.

General instructions are to fire 3 times an hour in amounts according to load: shake the grate every 2 hr., not enough to let red coals down on grate, but just a little to let air through the ashes. In starting up in the morning and at noon the slice bar is run under the fire to break up clinkers which may have attached to the grate. The rate of combustion varies from 16 to 24 lb. per sq. ft. per hr.



BATTERY OF DILLON-MANNING BOILERS

Pennsylvania run-of-mine coal is used which has a heat value of about 14,500 B. t. u., and tests 17 per cent volatile matter. The ashes average 9 per cent by weight of the coal burned.

Before coal is contracted for every year samples of 100 tons are secured from various dealers and these are tested out, the amount of the sample lasting about a week. The first few days give the firemen a chance to get used to handling the coal and the results of the last few days are taken for comparison.

Draft at the base of the stack is about 0.5 in., 0.2 in. is lost through the economizer, and over the fire the draft runs about 0.2 in. An automatic damper regulator is employed but never allowed to close the breeching entirely.

Plant Records and Tests

Coal is weighed on platform scales as it is brought to the firing floor in a wheelbarrow. The water is measured by a city meter. Once a year an all around test is made of the plant and at this time the steam developed is checked up from indicator cards taken from the engines. There is no means for measuring the steam except as above.

A record of feed water temperature is kept which ranges from 224 to 230 deg. as it goes from the economizer to the boiler. In a closed heater, taking exhaust steam from the condenser engine, the water is raised to 110 to 120 deg. depending on the vacuum carried on the main engine.

During times of testing the gases leaving the boiler vary in temperature from 450 to 470 deg., and drop 200 deg. in the economizer.

One Green fuel economizer is installed which consists of 384 4-in. tubes, 8 ft. long. A turbine is run through these tubes once in 2 yr., but the economizer is blown down twice a week and cleaned thoroughly twice a year.

The flue gases are analyzed with an Orsat instrument occasionally, but the results are so variable that the engineer does not consider the analysis of any great value.

Treatment given the water consists in feeding a little sal soda drop by drop into the feed line. The principal impurity is a very small amount of carbonate of lime.

Four of the 5 boilers are kept in operation while one lies idle; by this program each boiler is out of service one week in five, during which time it is cleaned. It is cut out of service on Saturday and allowed to stand until the next Saturday with the water in it when it is washed down with a stream of water from a hose and the water leg cleaned with a scraper. The boiler is then examined thoroughly and filled ready for starting up.

The flues are blown every morning with Vulcan cleaners while the boilers are in operation.

Coal comes to the yard on an elevated track and is dumped from drop bottom cars. From the yard it is carried in wheelbarrows to the boiler room where it is weighed and dumped on the floor handy for the stokers.

Ashes are removed every night in wheelbarrows and their weight kept as record.

There being no brick work, there is no chance for leaky boiler settings, and radiation is prevented by thoroughly insulating the boiler shell.

"Here, take some of these figures with you," the chief reminded me, "they are from my annual report, the average load, 1744 hp., was obtained from 2 sets of indicator cards taken on Monday and Wednesday of each week for the period of the full year's term."

And here is a summary of the report which he handed me:

Cost of coal per ton	$4.50
Average horsepower	1744

Cost of Power

4,229.57 lb. coal per horsepower per year (including banking and heating)	$ 8.46	
Labor	2.92	
Supplies and repairs	1.11	
		$12.49

Total Operating Expenses	
Depreciation and interest	$ 4.01
Taxes	.72
Insurance	.04
Total fixed charges	4.77
Total gross cost	$17.26
Deduct cost of heating	.58
Total cost 1 hp. per year	$16.68
The cost per i.hp.-hr	$.0058

Considering the size of the plant and that it is in operation only 56 hr. a week, the cost of power is exceptionally low. The steady load and the small amount of steam needed for feeding the boilers, both tend to bring down the overall cost of power. Credit, however, must be given the operating force for its share in maintaining high economy.

Efficient Orders

Two Methods of Giving Instructions, and Possible Effects. By J. H. Blakey

"SEE HERE, John," says the boss, coming into the engine room some morning with a blueprint in his hand, "these bearings need adjusting; those glands there ought to have new packing; those bolts should have lock nuts on them; that steam pipe must be covered; we'd better have some shims put under those blocks,—" etc., etc., pointing while he talks to the various parts on the blueprint. "Get your men together and have these things attended to tonight so as to be ready for running again tomorrow morning."

The boss prides himself on being a man of few words; upon being "direct," getting through with the matter in hand and proceeding to the next with the smallest possible loss of time. He prides himself also upon his own personal efficiency; and there is no doubt of it, for he can, as he admits himself, get through twice as much work in a day as the next man. He is proud, too, of the fact that the men around the place are afraid of him, though he may not admit this.

John has never seen that blueprint before, and has had considerable difficulty in following these rapid-fire directions; if he had had a red pencil at hand he might have marked the different parts as they were mentioned, in order to assist his memory; but he didn't happen to have a red pencil at hand (one cannot carry every tool that may be needed in the day's work around on his person) and he didn't have time to get one. The boss is inclined to be impatient at times, and would probably have resented it if John had walked down to the desk at the other end of the room for that pencil while he was talking. When the boss is through, John would like to ask some questions, just to make sure that he has understood his orders aright; but the boss is in a hurry, as he always is, and moreover John knows by bitter experience that many a man has lost his job by asking questions which the boss may think unnecessary, seeing that the orders have been given clearly and definitely, at least from the latter's point of view. So John looks ruefully at the blueprint, which after a few moments' examination he finds to be the manufacturer's assembly drawing of his engines. He gets his pencil and marks as best he can the different parts which require attention, trusting to Providence that he has got them all, and sets to work.

Picture number one; now compare with this picture number two.

"Good morning, Jim, how are things going this morning?"

"Morning sir; she's doing fairly well, but I've been thinking it might be a good idea to repack those glands, and—"

"That's just what I've come to talk about. Here's the manufacturer's drawing of the engines; just look it over for a few minutes and I'll be back."

So saying, the boss is gone. Jim takes the blueprint, gets his pencil, and very soon has located every part of the engine on the drawing. In 15 min. the boss reappears.

"Well, Jim, do you think you have got the lay of the land?"

"Yes, sir."

"Those glands you were speaking of: right here. Mark 'em."

Jim puts his red cross on the blueprint.

"And that steam pipe, running from here to there; you see it better on the end elevation here."

Jim marks again, and finally has a complete record of the work to be done, in red crosses.

When morning comes, John MAY have attended to all the different directions given him, but I think I'd be inclined to bet on Jim. Why? Isn't the answer perfectly obvious?

Now let us analyze picture number two a little for the benefit of those who admire the "rapid-fire" or "direct" method. Jim's boss spends a little valuable time saying, "Good morning." Apart from the question of the value of the ordinary courtesies of life in business, let us consider Jim's mental action during the time the pleasant greeting is being given and the boss is getting ready to tackle the matter in hand. As a matter of fact, Jim has had time to detach his mind from whatever was occupying him a moment before, and to concentrate his attention upon what is to follow. Then he has the blueprint put into his hand and is given time enough to connect the different parts of the engines with the drawing. Now he is prepared, mentally and physically, to receive his instructions. In addition, Jim's boss will likely ask his opinions as he goes along, and will explain his reasons for wanting this or that done. The result is that Jim does his work intelligently, feeling rather that he is co-operating with those in authority than simply obeying orders. John, on the other hand, does his work in a perfunctory way; the motive force behind him being the fear of losing his job.

John's boss boasts of his own efficiency, but is everlastingly cursing the stupidity of the men under him. Jim's boss doesn't boast about anything; his men like him, and he does not seem to have much occasion to talk about their stupidity or inefficiency.

Now, Mr. Superintendent, are you John's boss or Jim's? Did it ever occur to you that the shortcomings of your men may be due, at least in large part, to your method of giving orders?

Surface Condensers*

FUNCTIONS OF THE CONDENSER AND POINTS OF DESIGN THAT AFFECT EFFICIENCY. BY C. F. BRAUN.

THIS paper analyzes the functions of the surface condenser, presents briefly the fundamental principles governing design, discusses rational ratings, and compares typical commercial designs.

The primary functions of a surface condenser are to reduce the back pressure on the exhaust side of a steam prime mover; to conserve and return to the steam generator, in the water of condensation, as many heat units as possible; and to remove air from the feed water, thus reducing pitting of boilers. In accomplishing these results the condenser must handle 4 separate fluids: steam, air (including other non-condensable vapors), water of condensation, and cooling or circulating water. As the desirable state of these several fluids is not the same, the problem at once becomes complicated. Briefly, the conditions to be approached are:

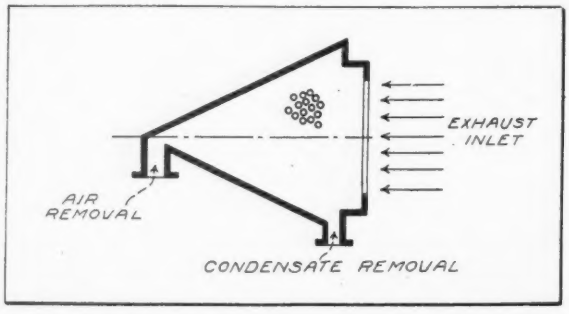


FIG. 1. THEORETICALLY CORRECT CONDENSER SHAPE

Steam should enter the condenser, be conducted freely to all parts with least possible resistance, reduced to the lowest practicable temperature (and consequently pressure) and converted into water.

Air, a non-conductor, should be rapidly cleared from the heat-transmitting surfaces, collected at suitable places, practically freed from entrained water and water vapor, and cooled to a low temperature for removal at minimum volume, with consequent least expenditure of mechanical energy.

Condensate should also be rapidly cleared from the heat transmitting surfaces, freed from air, collected at suitable points for removal, and returned to the steam generator at the maximum practical temperature.

Circulating water should pass through the condenser with least friction, deposit a minimum amount of precipitated chemicals or debris, and absorb a maximum amount of heat.

The main principle of design of the condenser is the transference of heat from the steam through the dividing surface to the cooling water. The transfer per unit of area or of size is a measure of the efficiency of the apparatus and is directly proportional to the temperature difference or head. The temperature of the water increases during its passage through the condenser, and that of the steam decreases; it is therefore necessary to obtain mean values for temperature differences. A simple arithmetic mean is not correct, but the following formula, developed mathematically by Grashof, has repeatedly been proven accurate and is almost universally adopted:

$$M = (D_1 - D_2) \div \log_e \frac{D_1}{D_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

M = mean temperature difference.

D_1 = temperature difference between fluids at beginning = $T S_1 - T W_1$.

D_2 = temperature difference between fluids at end = $T S_2 - T W_2$.

$T S_1$ = initial temperature of steam.

$T S_2$ = final temperature of steam.

$T W_1$ = initial temperature of circulating water.

$T W_2$ = final temperature of circulating water.

With any given set of temperature values the mean temperature difference can be varied in only one way, namely, by arrangement of heating surfaces. These must be such as to produce counter-current flow, the circulating water entering where the steam is coolest and leaving where it is hottest.

Transfer of heat through a unit of condenser tube area per unit of mean temperature difference was early recognized as varying greatly under different conditions, the most apparent variation being an increase with increase of water velocity.

RESISTANCE

THE TRANSFER of heat produced by the temperature head is opposed by a total resistance R, which, for analysis, divides conveniently into the resistance R_v on the vapor or steam side of the surface, the resistance R_m of the metal walls of the surface, and the resistance R_w on the cooling water side of the surface. A simple equation expressing heat transfer in useful terms may be written as follows:

$$R = \frac{M}{H}$$

in which:

H = number of heat units transferred per unit time

M = mean temperature difference

R = total resistance = $R_v + R_m + R_w$

The paper here considers the deduction of the resistances R_m, R_v and R_w and how they are influenced by design and by factors of operation, such as coatings of oil, air and scale, upon the condenser surfaces.

The variation of resistance, inversely with velocity, is due to the fact that the particles of water in contact with the surface at any instant from a nonconductor which prevents the flow of heat from particles in the body of the water to the surface of the tube. The transfer of heat is really by convection, and the more rapid the removal of the heated particles and their replacement by cooler ones, the greater the heat transfer. With the same velocity this transfer of particles is much more rapid in a small tube than a large one, where, so to speak, a cold core of water exists. This indicates the desirability of small tubes and experience dictates ¾ in. to ⅞ in. inside diameter as a maximum.

* Abstract of paper read before the A. S. M. E.

For apparent reasons of economical construction, most condensers consist of a cylindrical shell containing closely spaced round tubes. The water may pass through the tubes and the steam around them, or vice versa. While the steam circulates automatically as a result of condensation, the water moves only sluggishly, due to slight change of gravity with change of temperature. The arrangement, therefore, of passing the water through the tubes, is invariably employed, thus making it possible to give the water a rapid positive movement.

Among metals commercially available for use in condenser tubes, copper has the highest conductivity and where properly alloyed is less subject to corrosion than most others, thus permitting the use of thinner surfaces. Hence practically all condenser tubes are copper or high percentage copper alloy.

The size of tube is a determining factor in the thickness, larger tubes requiring greater thickness for mechanical strength, and from this viewpoint also small tubes are desirable.

The arrangement of heating surfaces for easy cleaning and the construction of water channel covers independent of pipe connections is important, although frequently neglected.

Steam passing over the tubes condenses and diminishes in volume as it progresses, and hence in ordinary condensers the steam flow velocity rapidly decreases and becomes practically nil in the portion away from the inlet, permitting air to stagnate. This steam flow velocity may be maintained by constructing a gradually reducing steamway, a triangle with steam entering over one entire side, Fig. 1, being theoretically correct, or by gradually reducing the pitch of the tubes or by making lanes or passages to various parts of steam space by omitting tubes, Figs. 2 and 3. Any one of these methods properly applied should be effective and result in good steam distribution at uniform velocities, prevent the stagnation of air at any point, and minimize the frictional drop.

If a liberal pitch be employed for the tubes, and ample lanes be provided, the frictional drop, even through a large condenser, need not exceed 0.4 in. and less in smaller ones. Figures 2 and 3 show proper distribution.

It is important that a sufficient number of air removal connections be located at points where air accumulates (Fig. 2).

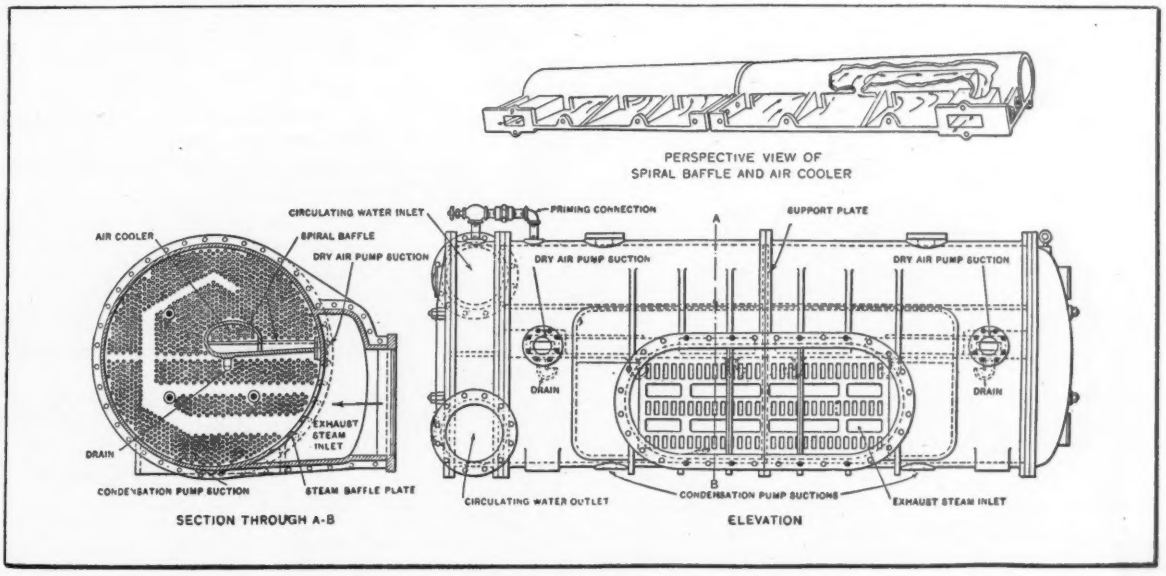


FIG. 2. WELL DESIGNED CYLINDRICAL CONDENSER

To prevent the formation of a coating of oil which has an effect more serious than a coating of scale, a fairly high steam velocity must be maintained over the tubes, and corners which become stagnant places must be eliminated.

The paper here considers typical designs of condensers, pointing out their advantages and defects.

An exhaust opening of liberal size with a dome extending the length of shell, Figs. 2 and 3 will cause the steam to be distributed to the ends of the tubes and prevent stagnant corners.

Baffle plates for directing the steam to remote parts of the condenser introduce resistance to steam flow and should be avoided, except for the small plate directly in front of the exhaust inlet to protect the tubes from entrained water in the exhaust.

The quantity of air allowed to enter a condenser should at all times be minimized and the importance of tight joints and pipe connections should be impressed upon operators. As only a very small quantity can enter with the feed water, it is evident that proper operating attention to the tightness of condenser shell, low-pressure stages of the turbine, piping and valves, will reduce the air in the condenser to a very low figure. If a large quantity of air were present in a condenser, it could be detected by vacuum and temperature readings taken at the same part of the steam space, the temperature indicated being that of the vapor, and the pressure that of the sum of the pressures of the vapor and of the air.

The resistance on the water side of the condenser could be eliminated if very high water velocities through exceedingly small tubes could be used. This, however, would cause a rapid increase of frictional resistance

and consequent cost of pumping, erosion of the tubes if the water contained sand, and an undesirable number of passes or a very long condenser. For these reasons a velocity flow is ordinarily limited to about 4 to 6 ft. per second. Experience shows 1 in. outside diameter to be the lower limiting size of tubes and this allowable only in very large condensers having a high circulating water ratio. Frictional loss may be minimized by using long tubes and fewer passes, reducing water passage and tube entrance loss.

Even distribution of water through all tubes is important and narrow channels causing high velocities or inlets directing water onto the tubes must be avoided, since uneven distribution is sure to result, those tubes not in the steam line receiving little water and being, therefore, largely ineffective.

There follows in the paper a consideration of condenser design with reference to desirable temperature condition and methods of removal from the condenser for each of the 4 fluids.

Steam must be maintained at the lowest practicable pressure, and hence the temperature must approach closely that of the circulating water discharge. There must be a difference, however, in order to produce heat flow; this should be kept within 10 deg. F.

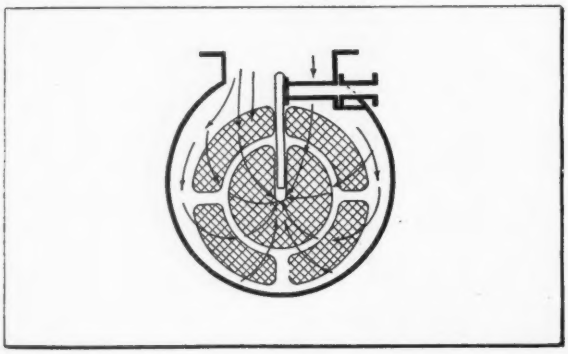


FIG. 3. CONDENSER GIVING TAPER PASSAGE EFFECT WITHOUT BAFFLES

Air must be removed from the condenser by a mechanical pump, the energy required for operation being directly proportional to the volume of air moved. This volume should be minimized by causing the air finally to pass over the coldest tubes.

Actual tests have proven that for ordinary wet vacuum pumps to handle the mixture of air, vapor, and water and maintain even moderately high vacuums it is necessary to cool the condensate 10 to 15 deg. below that due to the vacuum, which, of course, requires more circulating water and wastes more heat from the system. Another serious objection to the wet vacuum system is that compressing an emulsion of air and water is a most effective method of mixing the air with the condensate to return to boilers. Centrifugal air pumps having no clearance space, do not lose efficiency at high vacuums, and are rapidly coming into use, but the reciprocating type still has the advantage of requiring much less power for operation.

Condensate should be removed at a high temperature. Especially in large condensers, a number of condensate removal connections should be provided on the shell to insure free and quick flow to the removal pump, generally a centrifugal which, unlike a plunger pump, will handle varying quantities without speed changes, and which, if properly vented, never becomes vapor-bound.

Circulating water, to reach minimum quantity, must have an exit temperature closely approaching the steam temperature. The great effect of a comparatively small variation in this temperature may be appreciated by considering the maintenance of a 29-in. vacuum (79 deg. F.) with circulating water at 60 deg. F., the quantity required being twice as much if heated to within 14 deg. of the steam temperature, than if heated to within 9 deg., and the energy required to pump the circulating water being 8 times as much.

The best amount for this minimum temperature difference is always a compromise between condenser cost and pump and pumping cost, but with well designed apparatus should not exceed 10 deg. F. With poor designs, especially those having parallel flow, this difference is sure to be 15 to 20 deg. F. For service with circulating water obtained from cooling towers or other expensive source it might be warrantable to have this difference as low as 5 deg. F. The complete equation for the condenser is:

in which: $S = \frac{W \times Q}{M \times U}$ or $U = \frac{W \times Q}{M \times S}$

U = B.t.u. per sq. ft. per deg. F. difference per hour = coefficient of heat transmission.

M = Mean temperature difference in deg. F.

W = Pounds steam condensed per hour.

S = Square feet of cooling surface.

Q = Total heat removed by circulating water per pound steam condensed (usually taken as 1000 in all cases for simplicity).

Thus, for example, assuming results as follows from 2 condensers, we can say that A is 50 per cent more efficient than B.

	A	B
Square feet surface	2000	5500
Pounds steam condenses per hour	18,500	57,200
Vacuum	28½ in. (1½ in. abs.)	27
Temperature entering cooling water	65	60
Temperature exit cooling water	80	100
Mean temperature difference per equation (1)	18.3	30.9
B.t.u. per sq. ft. per deg. difference per hour	505	337

Items 3 to 6 determine the mechanical energy required by air condensate and circulating pumps. Item 7 indicates the heat efficiency, being a measure of the heat returned to the system in the condensate.

INSTEAD OF BEING entertained by the more or less interesting stories told by fellow workmen around a campfire, lumbermen employed by the large and up-to-date companies are now given free moving picture shows which break the monotony of camp life and aid in keeping the men on the job for the season.

TO ENLARGE a piston snap ring which has become worn, the ring may be removed from the piston, the outside, opposite the joint rested on a piece of softer metal such as copper, to avoid injuring the edges, and the inside peened lightly and repeatedly. This will tend to expand the ring and give a closer fit in the cylinder.

Electrical Machinery and Appliances

For Generating, Transmitting and Using Current

The Compensated Voltmeter

METHOD USED TO CAUSE VOLTMETER TO INDICATE DIFFERENCE OF POTENTIAL EXISTING AT SOME DISTANT POINT

ORDINARY indicating or recording station voltmeters inform the operator of the value of the voltage at the switchboard, but tell him nothing regarding the service at any point along the transmission or distribution line, and while he may be doing his utmost to give satisfactory service, he may fail in the attempt due to his inability to tell, until perhaps complaint reaches him, just what is going on along the circuits supplied with current. To overcome this, the compensated voltmeter, indicating or recording the voltage at any desired point along the line, is used.

The simplest and oldest device employed for this purpose is a pair of "pilot wires" carried between the

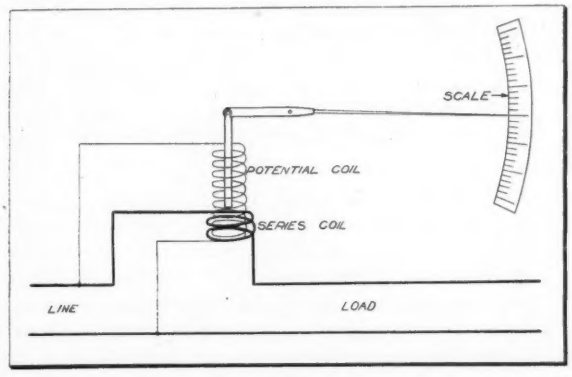


FIG. 1. SHOWING PRINCIPLE EMPLOYED IN THE DIRECT CURRENT COMPENSATED VOLTMETER

point of consumption and the switchboard. A voltmeter situated at the power house and connected to these wires indicates, or records, the voltage at the farther end of the line, thus allowing the generator voltage to be regulated accordingly. A great disadvantage of this scheme, however, lies in the fact that, as the distance of transmission increases, the cost of these pilot lines becomes prohibitive. In such cases, devices are used to show the operator voltage at the point of consumption without pilot wires.

DIRECT-CURRENT COMPENSATOR

WHEN USED on direct-current circuits, this consists as shown in Fig. 1, of an ordinary voltmeter provided with an auxiliary series winding, so connected that as the line current flows through the series winding, the field created thereby will oppose that of the potential winding so that the heavier the line is loaded the lower will be the voltmeter reading. The decrease in reading is proportional to the line current; the drop in line voltage is also proportional to the line current. By suitable adjustment of the number of series turns, or by properly shunting this winding, the instrument may be made to read the voltage at the receiving end of the line for every load.

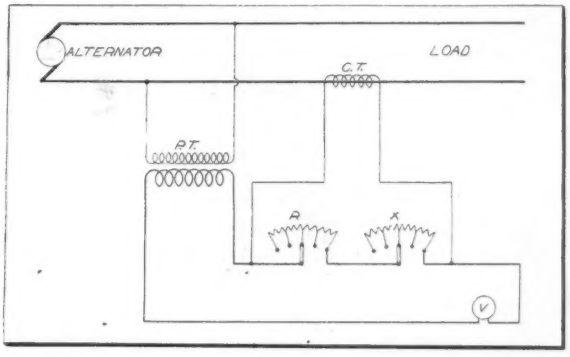


FIG. 2. DIAGRAM OF CONNECTIONS FOR THE ALTERNATING CURRENT COMPENSATED VOLTMETER

Due to discrepancies brought about by power factors less than unity, this instrument is not applicable for service on alternating-current circuits. For this service, another type of compensator is employed.

ALTERNATING CURRENT COMPENSATOR

REFERRING to Fig. 2, we see that voltmeter V is connected across the line through a potential transformer, PT, the secondary circuit of which includes an adjustable resistance, R, and an adjustable inductance, X, which in turn are connected to the secondary of current transformer, CT, as shown.

With the compensator correctly adjusted the voltage at the voltmeter terminals is the geometrical sum of the generator voltage as supplied by potential transformer PT, and of the voltage drop across the compensator, which latter is proportional to the line current and has the same induction and ohmic components as the actual line drop. The voltmeter, therefore, indicates the generator voltage less the line drop, or as may be stated, the voltage at the receiver end.

In Fig. 3, A, is shown the general relation of line voltage, generator voltage, resistance drop and reactance

drop existing in alternating-current circuits, where E is the generator voltage, E_1 the voltage at the end of the line or point of distribution, RI the resistance drop and XI the reactance drop. Then letting e, Fig. 3, B, be the secondary voltage of the potential transformer, and *ri* and *xi* the voltage drop across the resistance, R,

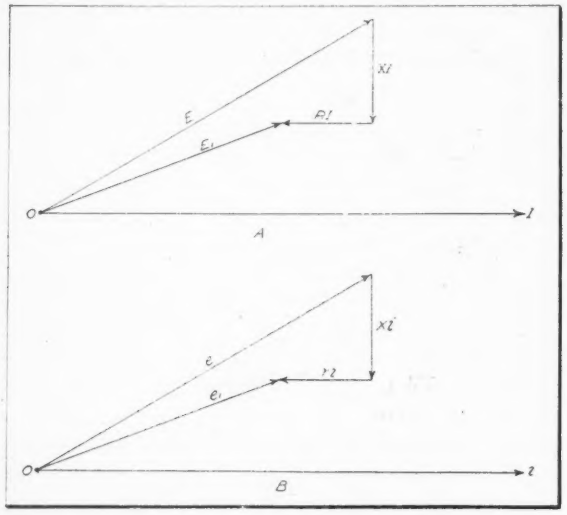


FIG. 3. GRAPHICAL REPRESENTATION OF THE SIMILARITY OF CONDITIONS EXISTING IN THE MAIN CIRCUIT AND THE VOLTMETER CIRCUIT

and reactance, X, of B, we find e_1, to be the voltage acting on the voltmeter. Then, since i has a fixed ratio to I, it is possible to adjust the inductance and resistance so that the vector diagram at B is exactly similar to that at A.

Operation of Transformers

QUANTITY AND PRESSURE OF AIR FOR AIR-COOLED UNITS; METHOD OF MEASURING PRESSURE; CONTROL OF AIR; WATER- AND SELF-COOLED TRANSFORMERS

AIR-BLAST transformers are generally intended for continuous service and are so designed that a low operating temperature is obtained by means of an air blast. The windings are inclosed and separate from the core, and both are constructed with numerous air passages. These transformers are usually mounted in cast-iron housings, which are provided with dampers for governing the cooling air, and with panels which give ready access to the terminals, coils and core for connecting, inspecting and cleaning.

Air-blast transformers are mounted over an air chamber into which air from outside of the building is forced by means of one or more blowers as shown in Fig. 1. The air pressure upward through the air passages in the transformer, thereby effecting the cooling.

Blowers are usually operated by direct- or alternating-current motors, either direct-connected or belt driven. Care should be taken to run the blowers at specified speeds since the power required to operate them varies as the cube of the speed. A slight increase of speed will, therefore, require a considerable increase of power, which may exceed the rated capacity of the motor. The pressure of the air for cooling transformers depends on their size, and is higher for large sizes, on account of the air ducts being longer and consequently of greater resistance. High-voltage transformers are larger than low-voltage units of the same capacity and frequency, and require a higher air pressure. The table, Fig. 2, gives approximately the pressure which should be supplied for operating these transformers.

For measuring air pressure a water gage is generally used, which consists of a bent glass tube, as shown in Fig. 3, the U-shaped portion being provided with a scale graduated in ounces, reading upward on one scale and downward on the other, from a zero point, located at the middle. One end of the tube is connected through a rubber hose to the chamber where the air pressure is to be measured and the other end is open to the atmosphere. Ordinarily the end of the rubber hose is inserted directly in the air chamber, but the inserting tube should be preferably used. This tube is made of insulating material and is closed at one end and perforated with a number of holes. The open end of the tube is connected to the hose. Figure 3 shows the complete outfit and its application.

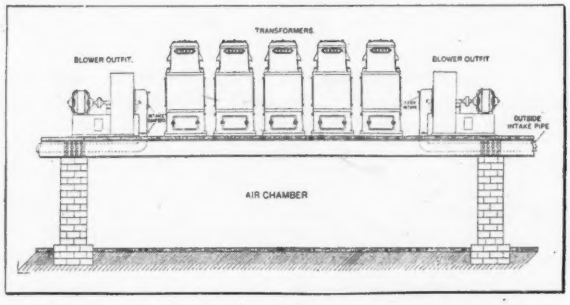


FIG. 1. TYPICAL AIR-COOLED TRANSFORMER INSTALLATION, SHOWING BLOWERS, DRIVING MOTORS AND AIR CHAMBER

For making observations, the U-shaped portion of the tube is filled with water to the zero line when held vertically, the difference of the water level of the 2 arms being a measure of the air pressure.

For each kilowatt loss, 150 cu. ft. of air per minute should be allowed; the volume of air required to cool a transformer may, therefore, be determined from the efficiency. For approximate volumes, only full-load efficiency need be known. Assume a 250-kw. transformer has an efficiency of 98 per cent, the approximate loss is 2 per cent, or 5 kw., therefore 750 cu. ft. of air per minute will be required to cool it.

In the operation of blowers for the cooling of transformers, considerable power may be saved by proper adjustment of the dampers. The cross-sectional area of the air ducts in air-blast transformers is considerably in excess of the area required for the pressure and volume of air specified for cooling it, but the proper regulation of air is obtained by adjustment of the dampers.

In cases where the air chamber, or duct, is long and of small cross-section, the pressure under the nearest transformer will, necessarily, be greater than the pres-

sure under those more remote. If, therefore, the dampers on all of the transformers were adjusted to the same degree of opening, the transformer nearest the blowers would receive the greatest volume of air, and if the blowers were run at a speed to furnish the most remote transformer with its proper supply of air, a considerable waste of energy would result.

Dampers of transformers located where the pressure is lowest should be opened wider than those where the pressure is highest; that is, the dampers should be adjusted so that the proper volume of air flows through each transformer. When the air supply is in excess of that required, and the pressure is approximately the same at every part of the chamber, the dampers should be set approximately as follows: Hinge type, 40 per cent open; single grate type, wide open. The dampers in air-blast transformers are so proportioned with respect to the losses that this adjustment may, in general, be made.

After adjusting the dampers the transformers should be closely watched until they have reached the maximum operating temperature. If the transformers are operating beyond the safe temperature, it can be easily detected by noting the temperature rise of the outlet air. This should not exceed 15 deg. C. when operating at full kilovolt-ampere capacity, and when operating at 1¼ normal full kilovolt-ampere load it should not exceed 23 deg. C. rise. The record of the degree of opening should be kept so that it will be possible to detect at any time if the dampers have been tampered with. Whenever a change has been made in the combination of operating transformers, it may be necessary to readjust the dampers so that all transformers have the same air pressure. The dampers of transformers not in use should be closed.

In case of a complete breakdown of a blower outfit, the transformers may be operated at approximately ½ normal load for periods not exceeding one hour. When operating without the air, all panels in the housings and all dampers should be opened and the maximum temperature of the coils not allowed to exceed 95 per cent of the normal value.

Care of Air Blast Transformers

If an air-blast transformer has been properly installed and operates successfully, it should continue to do so for a number of years if the proper care is given it. The dampers should be examined daily, particularly at installations where others besides the regular attendants are allowed to enter the room. The temperature of the outlet air should be noted at frequent intervals as its rise will indicate whether the transformers are receiving their proper supply of air. If the outlet temperature at normal load is more than 15 deg. C. above that of the surrounding atmosphere it indicates that the transformers are not receiving sufficient air, and an immediate investigation should be begun to locate and remedy the trouble.

In operation, air blast transformers collect dust and dirt in the air ducts and it is necessary to clean the transformer at frequent intervals. For this purpose every large installation should be provided with an air compressor capable of compressing the air to a pressure of 25 lb. per sq. in. The transformer should be cleaned at least once a month and more frequently if necessary.

The openings between the coils should be cleaned, where it is possible, with a felt swab and all outside parts brushed. When cleaning with compressed air, dampers with the exception of those used in cleaning, should be closed and the air should be blown through from the bottom.

In case it becomes necessary to repair a transformer winding, prepare in a suitable place a heavy bed of excelsior or straw, remove the transformer from its case and place it on the bed so that the weight of the coils will be largely taken by it. The bolts holding together the top and the bottom end frames should be removed, the top end frame taken off and the wooden wedges between the top of the laminated iron and the

60 CYCLES

KW.	VOLTS					
	2200	6600	11000	16500	22000	33000
125		½ OZ. PRESSURE				
150						
200						
250						
300						
375						
500		¾ OZ. PRESSURE				
750						
1000						
1500						
2000		1 OZ. PRESSURE				
2500						
3000						
3500						

25 CYCLES

KW.	VOLTS					
	2200	6600	11000	16500	22000	33000
125		½ OZ. PRESSURE				
150						
200						
250						
300						
375		¾ OZ. PRESSURE				
500						
750						
1000						
1500						
2000		1 OZ. PRESSURE				
2500						
3000						
3500						

FIG. 2. AIR PRESSURE TABLES FOR AIR BLAST TRANSFORMERS

coils driven out, and the laminated iron removed. As the laminations are removed, the coils will settle down gradually upon the bed below them, care being taken to see that the weight of the winding is not taken by the barriers which project from between the coils. When all of the iron is removed, the coils may be lifted out upon the floor and taken apart, when the necessary repairs can be made.

Water-Cooled and Self-Cooling Transformers

If the transformer is water cooled, see that the inlets and outlets of the cooling coils are properly connected, and that the water flows freely through the coils. Larger water-cooled transformers having the cover bolted down to the cast-iron ring riveted to the top of the case, are provided with an arrangement for reliev-

ing pressure inside the case if, for any reason, gas should be generated therein. This device usually consists of a cast-iron elbow to which is bolted a thin lead diaphragm. The elbow is bolted down over a hole in the cover, a lifting eye being removed for the purpose.

If, from any cause, an undue pressure should be set up inside the case, the lead diaphragm will blow out and leave the case uninjured. The diaphragm can be easily replaced in a few minutes' time. If desired, it may be fastened at the end of a piping system leading away from the elbow, instead of being attached to the latter.

After the transformer case is filled with oil and before the voltage is put on a new unit, it is advisable to run at about full-load current on short-circuit for a few hours until normal voltage is approximately reached. This procedure will usually drive out air bubbles and also dislodge moisture which may have found a resting place in the windings. Such operation does not, however, constitute a thorough drying out and is simply a precautionary measure taken before applying high-voltage for the first time.

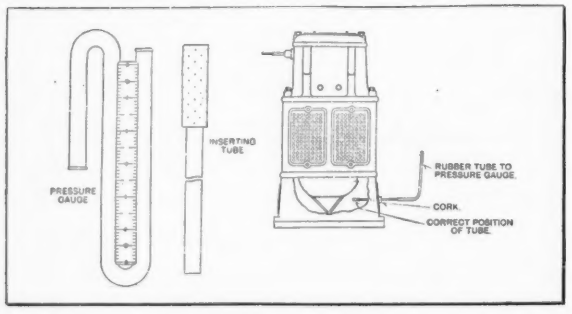


FIG. 3. U TUBE PRESSURE GAGE AND METHOD OF APPLYING TO TRANSFORMER CASE

When high voltage is first applied to a transformer, it should, if possible, be brought to its full value slowly so that any wrong connections or other troubles may be disclosed before damage can result. After full voltage has been successfully applied, the transformer should be operated in that way for a few hours before taking load from it. It should be kept under observation during this time and also during the first few hours that it delivers load.

If the transformer is water cooled, the main valve should be opened as soon as the voltage is applied. If there are 2 or more cooling coils in parallel, adjust the individual valves of the coils until an equal amount of water flows through each. This can be judged by inspecting the size of the discharge from each coil. A careful measure of the amount of water flowing through all of the coils should be taken and the flow adjusted to equal the amount set by the manufacturer.

After the amount of flow has once been adjusted the setting of the main valve should be marked so that it may be closed and opened again to the same amount. After the valves of the individual coils have once been adjusted for equal flow of water, they should not be touched again.

Every transformer should be shut down and tested at least once a year. See that the inside of the cover and the case above the oil are clean and dry and free from rust and that the thermometer bulb is thoroughly clean. If considerable dirt is found, it is an indication that dust has been working in through some crack or opening. Locate this and see that it is tightly closed.

If appreciable dirt or sediment is found in the transformer, it is best to take it out and remove the oil from the case. Both should then be thoroughly cleaned, and the oil filtered and tested. See that all bolts and nuts are tight and in cleaning use only clean, dry cloths or waste. If the transformer is water cooled, clean the cooling coils thoroughly and remove all traces of deposit of any kind that may have formed on them. Put the transformer and the oil in the case again and when the cover is placed in position, see that all cracks or openings are tightly closed.

When a water-cooled transformer is shut down for an indefinite period, or even for a short time in cold weather, the cooling coils should be emptied entirely of water and filled with oil. This can be easily done by unscrewing the unions at the ends of the pipes, turning up the elbows and pouring in the oil through an ordinary funnel.

In a water-cooled transformer, it is vital that the water be kept constantly flowing through the cooling coils during operation. If the water is shut off, the temperature of the transformer will rise very rapidly and will soon reach the danger point. If, for any reason, the flow of water stops, the thermometer should be carefully watched and as soon as it indicates a temperature of 75 deg. C., the transformer should be shut down. If allowed to run longer, the windings may be permanently injured.

Occasionally the quality of water used for cooling purposes is such that it will gradually form a deposit inside the cooling coils. This deposit is a poor heat conductor and will make itself known by increased temperature of the drying coil. This deposit or scale can be removed by running a solution of acid through the coils, hydrochloric acid generally producing the required results.

Transformer oil is shipped either in the transformer case, soldered in tin cans, or in steel drums provided with screw bungs which are sealed before shipment. The drums must always be placed on either side for transportation for storage. If stored out of doors, protection from the weather must be provided. Oil in drums which are not sealed must be tested before using. A drum of cold oil taken into a warm room will condense moisture, therefore the drum must be allowed to stand in the room long enough to reach room temperature before breaking the seal. All vessels used for transferring the oil must be absolutely dry and free from metallic or carbonaceous particles. Before using, all oil should be filtered through 2 layers of cotton cloth placed in the opening of a funnel. If there is moisture in oil it may be removed by passing through a bag of clean dry unslacked lime and afterward filtering.

ACCORDING TO the Electrician, an English firm of electrical manufacturers secured a contract for military supplies of some kind, the specifications for which required that cored holes should be made accurate to 3 decimal places.

Penny Wasting in Supplies

IN a paper before the Western Ice Manufacturers' Association, the matter of Leaks in the Ice Plant was discussed and small wastes which total large were pointed out. Among these were the following:

It is generally said that it is cheaper to buy oil than machinery, which is quite true, but it is my opinion that 75 per cent of the oil used is not necessary. It should be remembered that oil on the floor not only makes the place unsightly and unsanitary but it does not benefit the machine. In this item alone I have made some very thorough tests and am convinced that in most cases there is a wasteful use of lubricants.

There is scarcely a plant where you cannot find numerous fittings on dead ends left connected up from some change which are of no value at that point. In a great many cases you may go to your records and find that you have purchased just such material quite recently. I have in mind a case where a bill was submitted to my desk, in a plant where I had recently acquired the management, and upon taking it and carefully checking I found there were more than 50 per cent of the fittings about the plant. The lack of system is responsible for this, not a willful desire to waste on the part of the men.

In many stocks of packing you can find from 1 to 25 lb. of various kinds that have become so old they are absolutely worthless. This comes about in cutting gaskets from sheet packing; not keeping close to the edge; throwing the corner left out of the square when cutting a gasket for a 12-in. flange back into the stock, and not using it when cutting for a 2-in. flange instead of the original sheet. It takes only a small piece of rubber to amount to a penny or two. In the matter of ring packing the progressive tendency is to buy and try numerous new styles, and in a great many cases to an advantage, but as soon as a new packing has been found to be better than the style formerly used, what is on hand becomes a total loss.

A more concrete case of lack of appreciation of the loss around a steam plant might be illustrated in this manner: If you should chance to be about the office and notice those whose duty it is to count the cash drop a penny on the floor and not pick it up you would immediately come to the conclusion that the office force was wasteful, but I dare say you may go into any plant you care to and find from 1 to 50 fire bricks scattered about the premises as though they cost nothing, when as a matter of fact the least possible cost of a fire brick is 3 cents.

Another leak which is seldom taken into account is the indiscriminate use of the tools. Some men will use a 12-in. wrench where they should use a 16-in. and if they can not do the work with their hands they apply a piece of pipe which usually makes the wrench unfit for further use. This will apply equally as well to firing tools, wheelbarrows, and other accessories.

Deterioration, generally speaking, is another form of "leaks" that can hardly be measured. The greatest part of this comes from procrastination. The lack of properly protecting new ammonia condensers, steam condensers, pumps, cooling towers, drip pans and pipe work in general where there is any moisture, with paint when they are installed. This is equally true of all wood work about the plant. The drip from leaking valve stems over boilers, cutting away of valve seats from not being repaired when the leak first appears, scoring of piston rods from lack of proper attention, and many others, all come in for their share of general expense. Probably the worst feature of all this is the serious interruption of the operation of the plant at the time of the year when it can ill be afforded. How many times in your experience can you recall this statement, "We would have done real well last summer had it not been for the bad luck we had in our tank, melting out a box, or other things about the plant." Luck. There is no such thing. Why not face the proposition squarely by saying bad management. It is true there are the inevitable break-downs but, fortunately, they are in the minority. See to it that your plant is in proper condition before going into the season. The price of successful and economical operating of the manufacturing of ice depends solely upon Eternal Vigilance.

IN THE REFERENDUM vote taken by the Chamber of Commerce of the United States, on the desirable course with respect to the Seamen's Law, it was found that, on the question of Government Ownership and Government Operation, 88 per cent opposed this plan. On the policy of Government Ownership and Private Operation, the majority was strongly against it. As to Subsidies to Offset Extra Cost in operating vessels by private ownership under the provisions of the Seamen's Law, 75 per cent of the votes favored the principle. Many of the approving votes were, however, provisional, and asked for careful supervision of the subsidies, or favored this method only in case no other way of building up the Merchant Marine could be found.

In the matter of Subventions for Mail Steamers, 93 per cent approved the plan, and as to a Shipping Board, the majority were in favor. The Abolishment of Deferred Rebates was favored, and also the Filing of Schedules showing ocean freight rates, but there was considerable opposition to any activity in Congress attempting to regulate rates for ocean transportation. On the question of Making All Steamers running from American ports Take Out License, the vote gave preponderance in favor of the proposal. Ninety-two per cent of the votes favored the Lowering of the Speed Requirement for Steamers Carrying Mail, and a payment for this service which will be considered adequate. The question of Subscribing for Bonds by the Government to assist the development of a Merchant Marine, and then placing these bonds before the public through a development company, was not adequately determined by the vote.

In connection with this, some of the heads of steamship companies were asked to state their point of view in regard to the present Seamen's Law passed by the last Congress, and to go into effect Nov. 4. The comments of these men were, that the increase in expense involved by the new law would be such as to force present operating lines out of business, or to necessitate the transfer of the ships to the flag of some other country, and the opinion was also expressed that many of the ships which have been placed under the American flag under the permissive act of last year, would of necessity be re-transferred to some other flag.

Foundation Anchor Bolts for Machinery---IV.

HOLDING POWER OF RODS. BY TERRELL CROFT

HEADLESS BOLTS, without anchor plates or nuts at their lower ends, can be effectively used for relatively small machines where the foundations are of concrete. The adhesion of the concrete will (as will be shown later) if the bolt is imbedded in the concrete for a sufficient length, be great enough to prevent the withdrawal of the bolt.

Headless bolts should not be used in brick or stone masonry foundations, as the adhesion between the surface of the bolt and the foundation is so small that it offers but little resistance to the withdrawal of the bolt. Even if a brick or stone foundation is set in cement mortar, only a small portion of the imbedded surface of the bolt may be in contact with the cement mortar and there is practically no adhesion between the bricks or stone in the foundation and the surface of the bolt, hence an anchor plate should invariably be placed on the lower end of a bolt set in a brick or stone foundation.

The unit adhesion between iron or steel set in concrete varies from about 250 to 400 lb. per sq. in., in practice, a value of about 250 lb. per sq. in. being assumed as the ultimate strength. This means that for

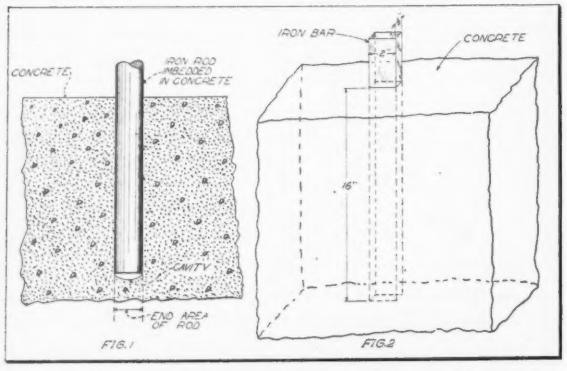


FIG. 1. ILLUSTRATING THE INEFFECTIVENESS OF END AREA
FIG. 2. ADHESION OF IRON BAR IN CONCRETE

every square inch of exposed surface of a rod imbedded in concrete, there will be an adhesion, that is a resistance to withdrawal, of something between 250 and 400 lb. per sq. in., but assuming a factor of safety of about 3 to 5 the *safe* adhesion will be 75 lb. per sq. in., and in reinforced concrete work it has been authoritatively recommended that the safe adhesive strength between mild steel, or iron rods and the concrete in which they are imbedded, may be taken as 75 lb. per sq. in. of exposed surface.

These values are for plain round or square bars. In computing the effective adhesion surface of a rod, the surface at the end of the rod is neglected because, as shown in Fig. 1, there is practically always a cavity under the end of every rod set in concrete. The surface of the rod in contact with this cavity or air pocket is of course ineffective as regards adhesion.

The adhesion between any iron rod and the concrete in which it is set can be computed from the following formula:

$$(1)\quad p = a \times A \text{ (pounds)}.$$

$$(2)\quad a = \frac{p}{A} \text{ (sq. in.)}$$

$$(3)\quad A = \frac{p}{a} \text{ (pounds per sq. in.)}$$

Where p = the adhesion of the concrete to the rod, in pounds, that is, the pull, in pounds, necessary to withdraw the iron or steel rod from the concrete, a = the area of surface of the sides of the rod in contact with the concrete. A = the unit adhesion, in pounds per square inch, between the rod and the concrete, values for which are given in a preceding paragraph.

EXAMPLE.—How many pounds pull would be required to withdraw from the concrete the ½ by 2-in. iron bar of Fig. 2, which is set in the concrete for a distance of 16 in.?

SOLUTION.—The area of the sides of the rod in contact with the concrete is: $16 \times (2 + 0.5 + 2 + 0.5) = 16 \times 5 = 80$ sq. in. Assume from the preceding paragraph a unit adhesion of 250 lb. per sq. in. between concrete and iron. Now, substitute in Formula (1):—

$$p = a \times A = 80 \times 250 = 20{,}000 \text{ lb.}$$

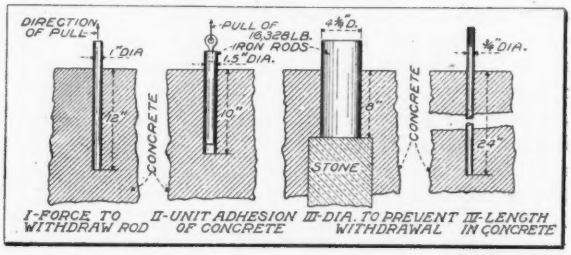


FIG. 3. EXAMPLES OF ADHESION OF CONCRETE ON IRON RODS

The adhesion, or resistance to withdrawal, of a round iron or mild steel rod set in concrete (the adhesion of the end area of the rod not being considered) is given in the following formula:

The superficial area of any cylinder = 3.14 × d × l, where d is the diameter and l the length, from which it follows that:

$$(4)\quad P = A \times 3.14 \times d \times l \text{ (pounds)}.$$

$$(5)\quad \text{therefore: } A = \frac{P}{3.14 \times d \times l} \text{ (lb. per sq. in.)}$$

$$(6)\quad \text{and: } d = \frac{P}{A \times 3.14 \times l} \text{ (inches)}.$$

$$(7)\quad \text{and: } l = \frac{P}{A \times 3.14 \times d} \text{ (inches)}.$$

Wherein: P = pull in pounds necessary to withdraw —or the resistance to withdrawal of—the round iron or steel rod set in concrete. A = The adhesion of concrete to steel or iron in pounds per square inch. l = length, in inches, of the portion of the rod set in the concrete. d = the diameter of the rod, in inches.

EXAMPLE.—How many pounds pull will be required to withdraw the round rod of Fig. 3, I, from the concrete? The rod is 1 in. in diameter and is set in the concrete for a distance of 12 in.

SOLUTION.—Assume 250 lb. per sq. in. as the adhesion of the concrete to the steel. Substitute in the formula (4):

$$P = 250 \times 3.14 \times 1 \times 12 = 9420 \text{ lb.}$$

Therefore, a pull of about 9500 lb. would withdraw the rod.

EXAMPLE.—If a pull of 16,328 lb., Fig. 3, II, withdraws a 2-in. diameter round steel rod set in concrete a distance of 10 in., what is the adhesion in lb. per sq. in., of the concrete to the rod?

SOLUTION.—Substitute in Formula (5):

$$A = \frac{16{,}328}{3.14 \times 2 \times 10} = \frac{16{,}328}{6.28} = 260 \text{ lb. per sq. in.}$$

Therefore, the unit adhesion of the concrete to the iron with conditions as above, is 260 lb. per sq. in.

EXAMPLE.—It is desired so to set a rod in concrete that it will safely withstand a pull of 5000 lb. Conditions are such that the rod can extend only 8 in. into the concrete. If it is to set 8 in. into the concrete, what must be its diameter so that the total adhesion between it and the concrete will be sufficient to prevent the pull of 5000 lb. from withdrawing it?

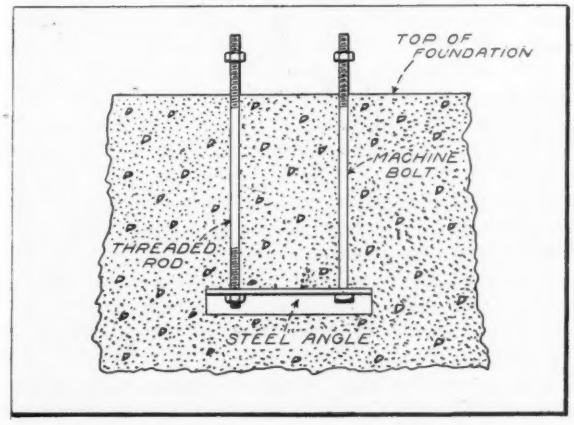


FIG. 4. ANCHOR BOLTS AND ANGLE-IRON ANCHOR

SOLUTION.—Assume a factor of safety of 6. Then the *safe* unit adhesion of the concrete to the rod will be $250 \div 6 = 41.7$ lb. per sq. in. Now substitute in formula (6):

$$d = \frac{5000}{41.7 \times 3.14 \times 8} = \frac{5000}{1047.5} = 4.78 \text{ in.}$$

Hence, the rod should be 4.78 in., or say 4¾ in. (as shown in Fig. 3, III) to provide sufficient adhesive surface to prevent withdrawal under the conditions of the example. This is an extreme case and one that would probably not occur in practice. It is given to illustrate the principle.

EXAMPLE.—A ¾-in. diameter mild steel bolt has a probable breaking strength of about 14,000 lb. How far should such a bolt be set in concrete so that the adhesive strength between the concrete and the bolt will just equal its probable breaking strength?

SOLUTION.—Assume unit adhesion of concrete = 250 lb. per sq. in. Substitute in Formula (7):

$$l = \frac{14{,}000}{250 \times 3.14 \times 0.75} = \frac{14{,}000}{588.7} = 24 \text{ in.}$$

Hence, the ¾-in. rod should be set in the concrete for a distance of at least 24 in.

The tensile strength or supporting power of a round iron or mild steel rod, before stretching, assuming the elastic limit of this material to be 25,000 lb. per sq. in. is:

$$(8)\quad T = \frac{25{,}000 \times 3.14 \times d^2}{4} \text{ (lb.)}$$

$$(9)\quad \text{or: } T = 6250 \times 3.14 \times d^2 \text{ (pounds).}$$

Where T = supporting power in pounds and d = diameter of the rod in inches.

A mild steel bolt has an elastic limit of about 25,000 lb. per sq. in. and will yield excessively if stressed beyond this value.

The depth to set a rod in concrete so that its supporting power is just equal to the adhesion between it and the concrete can be computed as indicated below. For the condition just stated to be satisfied, it is obvious that the adhesion of the concrete to the rod should be just equal to the strength of the rod, that is:

$$(10)\quad P = T.$$

Taking 250 lb. per sq. in. as adhesion of concrete.

$$(11)\quad 250 \times 3.14 \times d \times l = 6250 \times 3.14 \times d^2.$$

$$(12)\quad 250l = 6250d.$$

$$(13)\quad l = 25d.$$

It is apparent, therefore, that to insure against the withdrawal of a round iron anchor bar, it should be set in concrete a distance at least equal to 25 diameters. Theoretically, such a rod would pull out when the stress on it became equal to 25,000 lb. per sq. in. It should, however, be noted that in the above computation it was assumed that the rod was not threaded. A threaded rod is obviously weaker than when unthreaded.

Inasmuch as the strength of bond between a rod and the concrete in which it is imbedded is a somewhat uncertain factor, plain rods to develop their strength should for safety be imbedded somewhat more than the theoretical distance, 25 diameters, and the value of 30 diameters is believed to be a conservative practical figure. Where an anchor bolt rod imbedded in concrete has a head on its lower end, that is, where a machine bolt is used, it is probably the best practice to disregard the resistance to withdrawal due to the shearing tendency of the head when a tension is imposed on the bolt, and treat such a rod as a plain rod without a head.

An angle-iron anchor plate, or similar arrangement, greatly increases the equivalent adhesion of bolts solidly imbedded in concrete, Fig. 4. In this illustration, one of the bolts is a threaded rod and the other a standard machine bolt, and while a steel angle constitutes the anchor at their lower ends, any piece of metal long enough to engage the lower ends of 2 or more bolts and of sufficient transverse strength can be used instead. This method is particularly useful when foundations cannot be made very deep, it can be applied in concrete or in brick or stone masonry, and it is used to a considerable extent in structural steel mill buildings for anchoring columns to their footings.

(To be continued.)

International Engineering Congress

ON Sept. 20, the sessions of the International Engineering Congress will open in San Francisco, all sessions being held in the Auditorium Building, Hays and Larkin Sts., at Market St.

The opening general session will be held at 10 o'clock Monday morning with address of welcome by the mayor of San Francisco, by Gen. Geo. W. Goethals, who will preside over the congress, and the John Fritz medal will be presented to Dr. James Douglas.

A closing general session will be held Saturday morning Sept. 25.

The Engineering Sessions will begin at 2 o'clock Monday afternoon, and continue throughout the week. The sessions will be by departments according to the subjects treated. A general session on Monday afternoon will be devoted to the Panama Canal, papers being presented by Gen. Goethals as an introduction, by Emory R. Johnson on Commercial and Trade Aspects, by Capt. R. E. Wood on The Working Force, by F. C. Boggs on The Purchase of Supplies, by D. F. MacDonald on The Canal Zone Geology, and by F. D. Wilson on Climatology and Hydrology.

One section of the congress will be devoted to Waterways and Irrigation. The first session will be held on Tuesday morning at 10 o'clock covering the provisions of waterways, construction of artificial waterways and natural waterways in the United States. The afternoon session at 2 o'clock will cover flood control in the United States and in China, river improvement in Japan. Wednesday morning session will deal with dry excavation, dredging in Panama, construction of the Panama Locks, dams and spillways, by officers of the engineering force of the canal.

Thursday morning this section will take up the design of locks, dams and regulating works and the methods of locking operations, and Thursday afternoon will consider irrigation enterprises in the United States, Italian irrigation and methods of distribution.

Friday morning will take up irrigation in India, the construction of dams and using underground waters, and Friday afternoon, irrigation in Australia and in Spain.

Saturday morning the session will deal with irrigation in Argentine and with drainage as related to irrigation.

The section of the congress devoted to Municipal Engineering will begin its sessions Tuesday afternoon at 2 o'clock.

The section devoted to Railway Engineering will hold its first session on Tuesday morning, the second session Tuesday afternoon, sessions Thursday morning and afternoon and Friday morning. Papers will be presented covering the present status of railways in North and South America, Italy, India, China, Russia, the East Indies, the construction of tunnels in Italy and Switzerland, economics of building new railway lines, locating of the lines, track and road bed, bridges, rolling stock, railroad terminals and electric motive power.

The section devoted to materials of engineering construction will hold sessions on Tuesday morning and afternoon, Wednesday morning, Thursday morning and afternoon and will discuss papers on timber as used in the United States and Canada, in India and in Russia, the preservation of timber, clay products, various details of concrete construction, the outlook for iron, the use of alloys in engineering, the world's copper supply, and testing of materials.

The Mechanical Engineering section, which will be in charge of the American Society of Mechanical Engineers, will hold sessions on Tuesday morning and afternoon, Wednesday morning, Thursday afternoon and Friday morning and afternoon. Papers will be presented on foundry and forge shop practice, machine shop equipment and methods, power plant design, the internal combustion engine and the Diesel engine, steam turbines, water turbine practice, hydraulic power development, motor vehicles, equipment and methods of a boiler shop and the present-day boiler and the use of compressed air.

The section on Electrical Engineering in charge of the American Institute of Electrical Engineers will hold sessions on Thursday morning and afternoon and on Saturday morning. Subjects taken up will be electric power station design, industrial effect of low cost electric energy, effect of hydro-electric power transmission on economic and social conditions, electrical installations of the Panama Canal, electrolysis in engineering practice, electric motors and machine tools and illumination.

The section on Mining Engineering in charge of the American Institute of Mining Engineers will hold sessions on Wednesday morning and Thursday morning, dealing with exploration and development of mining properties, financing of mines, organization and operation of mines and mine inspection.

The Metallurgical section holding sessions on Tuesday afternoon, Thursday morning and afternoon and Friday morning and afternoon will deal with iron and steel castings, various processes of steel manufacture and the use of steel alloys, copper reduction and smelting in various countries, the treatment of copper ores and the refining of copper by electric processes, treatment of gold ores by different methods, the metallurgy of zinc and the utilization of fuels in metallurgy, particularly pulverized coal.

The section on naval architecture and marine engineering will be in charge of the Society of Naval Architects and Marine Engineers, and will have presented topics of ship resistance and propulsion, passenger lines, ocean freighters, lake freighters, sail, steam and motor yachts, war ships, torpedo boats and submarines, the marine boiler room and steam turbine, cargo handling, the use of the Diesel engine for marine propulsion, the use of fuel oil and terminal works, including dry docks and graving docks.

A section devoted to Miscellaneous subjects will hold sessions on Wednesday morning, Thursday afternoon, Friday morning and afternoon, and will include papers on aviation, refrigeration, agricultural engineering, engineering education and heating and ventilating.

Membership to the congress is open to anyone interested on the payment of $5, which includes membership and any one volume of the transactions. Each section of the congress will have its own volume of transactions and extra volumes may be secured according to the list of prices shown in the announcement of the congress and transactions in the advertising section of this issue.

Economizing on Oil

By K. Watt

"HELLO, Jerry! Glad to see you; it's been quite some time since we worked together down in the loop, eh?" thus spoke my old friend Pete when I ran in to see him at the ice plant, at the same time wiping the oil off his hands with a piece of waste and peering over the top of a pair of greasy spectacles. "Let's see, that was back in 1903 or 4, wasn't it?" continued Pete. "Say, you bring back memories of some comic things.

"Remember the old chief? Finest fellow you ever met, Frank was, but gee! he sure started some funny stunts. As I remember it, there were 3 engines altogether, a cross compound Corliss and 2 Buckeyes."

"That's right," says I, "and 3 6 by 4 by 6 boiler feed pumps, a vacuum pump and one fire pump, with 3 Stirling water-tube boilers with Hawley down-draft furnaces."

"Well do I remember," said Pete, addressing himself to his first assistant and me, "the first day I put in in that plant. We were running night and day, and my shift started at 2 p. m., and you relieved me at 12 o'clock midnight. Well, at 5:30 the day load dropped off and I changed over from the cross compound Corliss to the big Buckeye. The chief said good night and left me alone. Of course, I had a fireman, and as only part of the plant ran nights, there was a night watchman, named Fred, who made his headquarters in the engine room.

"You know how a fellow feels on a new job. He is on the alert, notes every little noise. Well, about an hour after the chief said good night, that Buckeye engine began to pound. I got busy looking for loose bearings. After feeling over crank and crosshead, I moved over to the valve motion side, and the noise was more pronounced here. It seemed to be in the riding cutoff or knuckle joint then. Jerry, you remember the force feed lubricators were all detached. Well, there was a hand pump just above the throttle valve; it held about 6 oz. of oil. I filled it and pumped the oil in, and soon there was less noise, but she kept me guessing until you arrived at midnight.

"We had never met before, so there was not much said that first night. I remember I asked what was the reason all the oil pumps were disconnected. Then I found out our chief did not believe in using cylinder oil; said it was an old exploded idea.

"Well, the next day I approached the chief on the subject. 'Yes,' says he, 'I have been in the U. S. Navy 10 yr. and have an unlimited tonnage license. We don't use cylinder oil any more. Why, we dismantled the engines on a gunboat, calipered the cylinders, put them together again and made an 18 months' cruise, dismantled again and found they had worn only 1/64 in., and had a fine case hardened smooth surface. No sir, no cylinder oil for mine.'

"Well, the idea was new to me, and I was young, yet that didn't help out on the Buckeye nor did it help the boiler feed pumps either, but we fooled the chief, eh Jerry? We hooked 'em up at night and unhooked 'em in the a. m., only on the pumps there was nothing to hook, they had been taken off entirely; say, did I swear at that pump trouble? Well I guess. Every day you left me a note saying this pump or that pump was down; look it over.

"And another thing our chief did. Made wood rings for the water end of the pump. Some stunt! No oil; hard wood rings that swelled up and took about 10 hp. to move. Oh yes, it was some job, believe me!

"The way the U. S. Navy could get by without using cylinder oil on her engines kept me guessing some for a while, until one day I met Sam Hill, who was chief on the old New York. Sam says that all ocean going ships have distilling plants on board and distill all the water they need for all purposes. Distilled water, you know, makes clean steam, no grit or scale at all, but to try that system on our old pumps and engines that we have been feeding cylinder oil for years, is like saying to Gus, the brewmaster over in Keeleys,—'Gus, you get no more beer.' Would Gus holler? Well, I guess yes, yet he could live just the same. So our engines ran but they put up a holler, a grunt and groan, and the feed pumps busted their rings on the steam end about once a week.

"Must you go, Jerry? Well, call again soon." And there I left Pete telling his assistant engineer how we land lubbers tried to make the marine engineering ideas of our old chief conform to a stationary plant.

The quality of the water that may be found at any point along the larger streams within or bordering the State of Illinois is shown in a report which may be obtained, on application, from the United States Geological Survey. The investigation that led to this report was carried on under co-operation between the Federal Survey and the State Water Survey of Illinois, and the report was first published several years ago as Water-Supply Paper No. 239, but the large demand for it has necessitated its reissue.

Illinois is well provided with water supplies, but nearly all of them are surface waters, and most of them are so greatly polluted as to be unfit for domestic use without purification. They also contain so much dissolved mineral matter and so much suspended material as to be unsuitable for many manufacturing purposes, yet by proper treatment they may be rendered safe for drinking and suitable for all industrial uses.

The average amount of water used each day in cities of the United States varies from 50 to 150 gal. per capita. Of this the amount used for drinking is not much over ½ gal. per capita. It is of the greatest importance that this ½ gal. shall be free from the germs of disease, notably those of typhoid fever, and shall be reasonably clear and reasonably free from taste. This is all that is required to make the ½ gal. a satisfactory water. But in planning a waterworks system for home, factory, or municipality it is not enough to know whether the water is safe for drinking. To determine the best water for all purposes, it is necessary to know the amount and character of the mineral matter it contains. Without such knowledge, no estimate can be made of the cost of purifying the water and making it suitable for drinking and for industrial uses. In this report, a large number of analyses of the various Illinois waters are given.

LETTERS DIRECT FROM THE PLANT

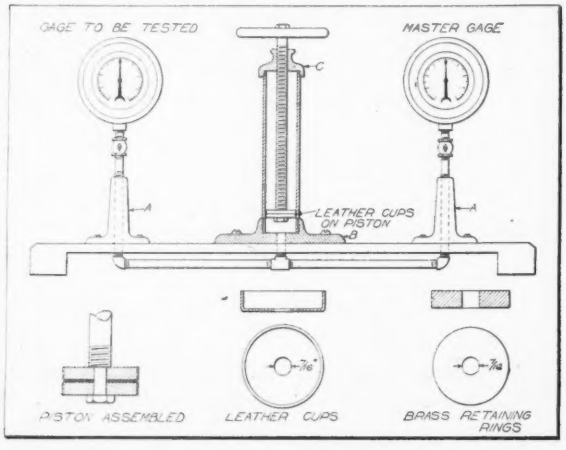
Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

Homemade Gage Tester

SOME TIME ago I was badly in need of a gage tester, as all of the gages in the plant, both ammonia and steam, were out to a considerable extent; some out as much as 18 lb.

This was a sorry state of affairs for the safe operation of the plant. I decided I wanted a gage tester so I could test the gages and correct them as soon as they evinced any signs of going wrong or getting out of order. I procured catalogs of gage-testing instruments, with prices, from the different manufacturers, and made out a data sheet (I had to bribe the bookkeeper to get this information) showing what it had cost this plant in the past for correcting and testing their gages. They always had sent the gages to the manufacturers for testing and correction, which is expensive, as anybody who has done the same will testify.

I showed by actual figures how a gage tester like the one I wanted would save its cost in a short time. After getting all the catalog data and facts together, I walked



ASSEMBLED GAGE TESTER AND DETAILS OF PISTON

into the office, saw the "lion in his den," told him what I wanted, and presented my dope with a few arguments.

The manager told me to put the soft pedal on gage testing apparatus for the present and come back and see him about it again after the war is over and he would see what he could do for me.

In the meantime I was to be allowed $15 to have the most important gages about the plant corrected and tested. This did not suit me very well; I had my mind made up to have a gage tester and I was going to have one some way or other.

After looking around for quite awhile for a second-hand tester and not being able to get one, I decided it was up to me to make one. I purchased a piece of 1¼-in. extra heavy brass pipe, 12 in. long; reamed it inside with a 1¼-in. reamer, which made an accurate and smooth surface on the inside of the pipe suitable for a piston to work in. Both ends of the pipe were threaded (24 threads per inch) about ¾ in. up on the pipe. This was done on a 7-in. foot-power lathe that we happened to have around the plant.

Next, I threaded a piece of ½-in. brass rod, 14 in. long, the whole length, and turned one end down to 7/16 in. diameter, about an inch long, threaded it for a standard 7/16-in. nut, and filed a square on the other end for a hand wheel. After finishing this, I turned up 2 brass retaining rings for the leather cups, as shown in the sketch. The leather cups were cut and made out of a sheet of rawhide 3/32 in. thick. This was for the piston.

I assembled the leather cups and the brass retainers onto the ½-in. brass rod and tried it in the bore for the pipe and it made a good, tight-fitting piston with a slight chance of leakage. After I found that this type of piston would do the work all right, I procured some maple wood in the carpenter shop and turned up the patterns for the parts marked A, B and C in the sketch. After I had them smooth by means of sandpaper and a good coat of shellac, I sent them to a brass foundry to be cast. When I received the castings, I turned them up as illustrated, and polished them nicely. This was all done on the lathe.

After finishing them up, that is, boring and tapping them, I secured them by means of wood screws to a maple base 18 by 8 by 1½ in., and connected the gage stands by means of ⅜-in. pipe and fittings to the base of the pump. In the meantime, I had purchased a 6-in. test or master gage.

After I had the whole apparatus assembled and the pump filled with lard oil, I tested it out on a gage, and it worked very well. I had to make only one change, and that was to put on a larger hand wheel, as it became difficult to screw down the piston after I had reached a pressure of 100 lb., with the small hand wheel. A wheel 5 in. in diameter did the work nicely up to 200 lb.

After a few tests, when I was reasonably sure that the apparatus would do the work required of it, I called out the manager to the engine room to see my contrivance. After I had showed it to him I presented him with an itemized list of the cost for the outfit, which came to $9. He was much pleased with it and graciously condescended to purchase a 40-lb. spring for our indicator set that I had been after him about for some time, which brought the total up to $14. The other dollar he blew in on cigars for the bunch.

In a few days he came into the engine room with a friend of his, a superintendent from a nearby plant, and showed him our new gage tester, the result of this visit was that I have to make a duplicate for this friend of his.

Below is the total cost of the apparatus outside of labor, time spent and the cost of the wood and ⅜-in. pipe and tee and 2 elbows:

Brass pipe, 1¼ by 12 in.	$0.20
½-in. brass rod	0.25
Test or master gage, 6 in.	6.50
2 ⅜-in. brass stop cocks	0.40
Cost of brass castings (rough)	1.65
Total	$9.00

C. E. ANDERSON.

Cutting In Boilers of Unequal Pressure

H. K. SCHOLEFELD, in the July 1 issue, invites discussion on the subject of connecting in boilers without equalizing the pressure. The writer agrees with Mr. Scholefeld that if the operation is properly done no danger exists in connecting in a boiler carrying higher pressure with one already in operation but under lower pressure; but the fact is indisputable, that as long as we allow conditions to exist where the safety of the operation depends on the skill and careful handling of the apparatus by the attendant, we are always inviting an accident and, as a rule, it will be forthcoming sooner or later. A man may go along performing the same routine work, day after day, and things work smoothly; but some day something unexpected has happened to change the usual conditions, and before he has time to realize the situation, the accident has occurred.

To illustrate, an engineer who was as careful as a man possibly could be, and fully aware of the tremendous force stored up in a steam boiler under pressure, went up on top of a boiler to open the header valve to turn steam into a large heating line. As a rule, any size stop valve on a boiler header does not turn any too easily, the packing around the stem generally being pretty well dried up and tightened; but in this particular instance the stem was well packed and lubricated and turned freely. In previously closing the valve, however, it had been jammed tight against the seat and the engineer had to apply his full strength to get it loose. When it let go suddenly something slipped and the momentum of the big handwheel spun the valve open a full turn before the engineer realized what had happened, and the results were startling. The sudden release of pressure set up a water hammer that lifted the boiler clear off its support on the side walls and damaged the rear arch to such an extent that it had to be rebuilt. In fact, it must have been as near to an explosion as a boiler could get without letting go.

Raising steam on a boiler and putting it in service is the most critical point in boiler operation and too much care can never be exercised. Experiments have shown that, under favorable conditions, water can be superheated considerably above the temperature corresponding to the pressure existing in the vessel without generating any steam, the same as it can be lowered in temperature many degrees below the freezing point without any ice being formed; but when brought into this state, the least disturbance, such as a small object being dropped into the water, will cause ice to form instantly. And no doubt many an explosion has been caused by thus superheating the water, at least it seems reasonable to draw such conclusions from the fact that many explosions take place just as a boiler is put in service after having been shut down for cleaning or repair.

If it is possible to superheat the water in a steam boiler, more favorable conditions could hardly be found than when a cold boiler is slowly fired up. No water is fed into it to cause any disturbance and no steam is drawn off and in some types of boilers under such conditions there is very little circulation of the water. The water just loads up with heat units, some of which perhaps go into superheating the water while the rest are generating steam and building up pressure at little disturbance to the mass of water in the boiler; if the pressure is suddenly released, there will be set up a commotion that may prove destructive both to boiler and surrounding objects.

Nowadays, gate valves provided with a bypass is generally the practice for large high-pressure header valves and with these valves there is small chance for causing any dangerous disturbance to the water in the boiler when it is put in service. Not all plants, however, are so equipped.

The writer has always looked at large sized safety valves as anything but a safe proposition, and there is no reason why they should not be substituted by 2 or more of a smaller size. And then the position of the valve itself should be considered. The writer has seen safety valves placed on steam drums directly over the front waterleg of water-tube boilers with the result that every time the valve popped, it would pick up a solid mass of water and keep it up for several seconds until the commotion caused by the sudden lift of the valve would finally settle down enough to give the steam a chance to escape. C. CEDERBLOM.

Pipe Under Tension

IN THE Aug. 15 issue, N. G. Near states that an eastern designer of power plants has evolved a method of counteracting the expansion in pipe lines due to a rise of temperature. By some means, a stress is put in the piping when cold that produces an elongation of 1/10 in. for every 10 ft. of length. It is intended that there shall be no compression in the piping when heated by the steam. Just how these results are to be accomplished and an account of their practical effects, would be interesting reading.

A 12-in. standard pipe has a wall thickness of 0.37 in. with a cross-sectional area of 14.58 sq. in. The material of which it is composed has a modulus of elasticity of about 29,000,000. To produce an elongation of 1/10 in. in a 10-ft. length of this pipe would require a pull of

$$P = \frac{0.1 \times 14.58 \times 29{,}000{,}000}{10 \times 12} = 352{,}000 \text{ lb.!}$$

For a smaller and thinner pipe, the load would be less and for a larger or thicker pipe it would be more.

Any method of applying a pull of 352,000 lb. to a

line of piping would cost far in excess of any possible return from the advantages gained. A tensile stress applied to a line of piping must, of course, be resisted by the connecting bolts. Standard piping of 12-in. diameter is connected by 12 7/8-in. bolts. Each bolt has a cross-sectional area at the root of the thread of 0.42 sq. in. As the piping in the example is under a stress of 352,000 lb., each bolt must resist a pull of $\frac{352,000}{12} =$ 29,333 lb. and the stress per square inch of area is $\frac{29,333}{0.42} =$ 70,000 lb. nearly. This is considerably more than the breaking load.

The stress of 70,000 lb. per sq. in. is that necessary to produce the required elongation of 1/10 in. per 10 ft of length. As stated, "there is no compression whatever in the pipes when under steam." Now, in order to accomplish this last effect, there must be an additional stress in the bolts that will make the joints steam tight. Assuming that a stress of 8000 lb. per sq. in. is necessary to render the joints steam tight, then the 8000 lb. must be added to the 70,000 lb. producing the elongation, making a total stress in the bolt of 78,000 lb. per sq. in. This is equivalent to a pull of 78,000 × 0.42 = 32,760 lb. in each 7/8-in. bolt.

To satisfy the requirements of a 12-in. pipe joint and limit the stress in the bolts to 8000 lb. per sq. in., there would be required 12 bolts with an area at the root of thread of $\frac{32,760}{8000} =$ 4.095 sq. in. The nearest commercial size is a 2¾-in. bolt.

Fancy a 12-in. standard flanged joint connected by 12 2¾-in. bolts! I think I shall continue to pin my faith on pipe bends and expansion joints.

C. O. Sandstrom.

Allowable Loads on Staybolts

The recent amendments to the Massachusetts Boiler Rules require all staybolts to be drilled at both ends, "to a depth of not less than ½ in. inside the boiler plate, and diameter not smaller than 3/16 in."

A tell-tale hole in the ordinary rigid staybolt is unquestionably an advantage in giving warning that a bolt is broken or fractured; but, in laying down a hard and fast rule that all bolts shall be drilled at both ends, the Boiler Committee has effectually shut out the flexible staybolt. This form of staybolt is used to a great extent in locomotive boilers, where it undergoes and has successfully withstood the severest service. It may be of interest to the Massachusetts Boiler Committee to know that there is no record of a flexible staybolt breaking in service.

In the Massachusetts Boiler Rules there appears a table of allowable loads on staybolts of various diameters. It is stated distinctly in the "Rules" that the allowable load shall be based on the area of the bolt at the bottom of thread; yet, should a manufacturer send in a report of a boiler stayed in accordance with this table, he would soon learn that his boiler does not conform with the law and that the load on the staybolts must be based on the area at the root of thread, minus the area of the center hole.

The writer has been caught by one of the vagaries of the staybolt rule, and since, to our positive knowledge, there has been no official notice of this special ruling sent to manufacturers and inspectors, the opportunity is taken to make it known through the columns of Practical Engineer.

A table giving the net area of staybolts with 3/16-in. center holes and allowable load in pounds is presented herewith:

Net Cross-Sectional Area in Square Inches of Staybolts with 3/16-in. Center Holes and Allowable Load in Pounds

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5
Ten Threads per Inch				
1 1/4	0.911	0.883	5739.5	
1 5/16	1.019	0.991	6441.5	
1 3/8	1.134	1.106	7189.0	
1 7/16	1.255	1.227	7975.5	8589.0
1 1/2	1.382	1.354	8801.0	9478.0
1 9/16	1.515	1.487	9665.5	10409.0
1 5/8	1.655	1.627	10574.5	11389.0
Twelve Threads per Inch				
3/4	0.288	0.260	1690.0	
13/16	0.351	0.323	2099.5	
7/8	0.419	0.391	2541.5	
15/16	0.494	0.466	3029.0	
1	0.575	0.547	3555.5	
1 1/16	0.662	0.634	4121.0	
1 1/8	0.755	0.727	4725.5	
1 3/16	0.855	0.827	5372.5	
1 1/4	0.960	0.932	6058.0	
1 5/16	1.072	0.944	6136.0	
1 3/8	1.190	1.162	7553.0	
1 7/16	1.313	1.285	8352.5	8995.0
1 1/2	1.444	1.416	9204.0	9912.0

Col. 1. Diameter of staybolt in inches at top of thread.
Col. 2. Area at bottom of thread in square inches.
Col. 3. Net area of bolt equals area at bottom of thread minus 0.028 sq. in.
Col. 4. Allowable load at 6500 lb. per sq. in. cross-sectional area.
Col. 5. Allowable load at 7000 lb. per sq. in. cross-sectional area.

C. J. C.

Belts Should Run Faster

Belt and pulley manufacturers still persist in designing and computing for a maximum belt speed in the neighborhood of 4500 to 5000 ft. per min. Why they do this, I do not know, unless for the reason that such is the speed laid down by our ancestors.

In the steam field, electric field, manufacturing field —almost everywhere—speeds have been increased, and with increase in speed has come the accompanying increase in efficiency. Take, for example, the steam turbine and its speed relation to the old type reciprocating engine. Take the automobile engine and compare it

with the stationary engine. This is a high speed age.

It has been proved that belt transmission is highly efficient at speeds up around 12,000 ft. per min. Belts do not slip so easily at high speeds. Belt widths may be much reduced and total costs may be reduced.

With anti-friction bearings, small shafts, narrow belts, large pulleys, and high speed, you have a highly efficient belt transmission system at low cost.

N. G. NEAR.

Remedy for Trouble in Air Refrigerating System

THE DISCUSSION in the Aug. 1 issue on Dry Air for Power Uses was very interesting, and reminds me of an experience along this line.

It was my good fortune to be sent out with a refrigerating engineer to remedy trouble in an air refrigerating system to prevent it from freezing.

The plant was located on the south shore of Long Island, a place noted for its extreme humidity, mainly due to the sea fogs. At times, the air outside the engine room at night is so saturated that one unfamiliar with this part of the country would call it a drizzling rain.

The air which was used at the freezing cans, had to pass through a tube, about 1/16 in. diameter, and surrounded with water at the freezing point, so that extreme care was necessary.

When we arrived, we found that they had the compressor suction near the floor, and the air receiver close to the compressor. They also had a dehydrating coil with a drip drum between the receiver and the freezing cans.

The first thing that we did was to pipe the suction intake up to near the under side of the roof, then we built a dam around the receiver and placed a water spray on top. We also placed a separator near the dehydrating coil.

We tested this system for a week, during which time we noted at what points of the system most of the moisture could be removed, by draining each part once every hour. We found that most of the moisture settled in the receiver; at the separator we could detect only a little, but at the drip drum we were able to remove a fair amount. No trouble was experienced at the freezing cans, which proved that the air was fairly dry when considering the temperature of the air at this point.

This experience proves to me that for that plant, cooling the air at the receiver was advisable.

HERMAN VETTER.

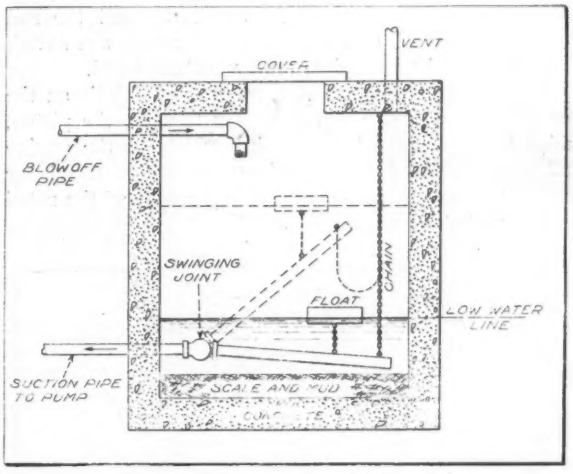
A Blowoff Well

THE RECENT agitation concerning the proper method of blowing down boilers shows that engineers are trying hard to get away from that old cut-and-dried rule of blowing down by the clock, or of blowing so many inches of water out every day, regardless of the condition of water, the cost of it, or the heat units carried away to the sewer. Some engineers have an idea that they couldn't do business without a blowoff line connecting their boilers to the sewer.

I've seen lots of elaborate steel blowoff tanks, but the best one I ever saw was a homemade concrete affair. It didn't need any sewer. Anyone can easily figure out the good points of it by a study of the accompanying sketch. The walls should be thick, as the thicker they are, the longer the heat will be retained.

If the boiler feed pump is used to pump the water out of the well, the bottom of the well should be on a level with the pump, if not higher. If possible, the well should be entirely underground. The chain prevents the suction pipe from going too low and becoming clogged with mud or scale. The float can be adjusted to hold the pipe any required distance below the water level. The swinging joint is simply 2 elbows and a nipple with the nipple tight in one ell and loose in the other.

The suction pipe, float, chain, etc., should be as close to one side as possible to be out of the way when the well is being cleaned out. The blowoff pipe should enter near the top of the well and extend until under the manhole or door and then turn down with an ell



HOMEMADE CONCRETE BLOWOFF WELL

and a nipple. A cap should be firmly screwed on this nipple before a man enters the well—"Safety First." The well should be large enough to hold all the water from one boiler, then when a boiler was to be killed, it could be emptied into the blowoff well and after the water had settled, it could be used again at a high temperature and it would be almost pure and free from scale-forming matter. The water blown out of the boilers every day could be allowed to settle for an hour or so and then pumped back into the boilers. Think it over. If any of you know of a blowoff well that is better than this one, I'd like to see it. F. R. DALY.

(Mr. Daly evidently overlooks the saturated condition of the water in the well. An analysis of this water would surely prove it to be unfit for feeding boilers.—EDITOR.)

Packing is Taught by Experience

AS FAR AS I know, the "science of packing" is not taught in our colleges.

After graduation, my first job was that of running an engine. It needed packing, and so I went downtown and bought some. I just asked for "———" packing, because I had seen it advertised. The dealer handed me a paper box on which was marked the name I sought.

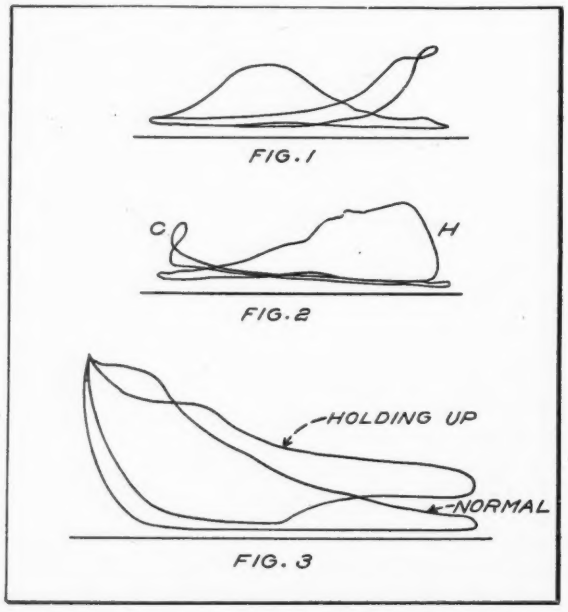
"Very simple, indeed," thought I. But when it came to putting the packing around the piston rod and in the stuffing-box, I found it was too thick. I should have asked for half-inch stuff, whereas this was ¾-in. in thickness. Even then I did not tumble. I thought all packing must be that size and that it was up to me to squeeze it in, which I did by means of a hammer. I laid the packing on an anvil and hammered it until thin enough all along to go into the box. Then I put it in, cut it off, screwed up the gland, turned on the steam and away we went again. It *worked* b'dad! But I learned later that packing of correct size works best, lasts longer, and does not absorb so much good power.

N. G. NEAR.

Friction and Engine Economy

IN REGARD to this matter, there is no end of evidence. The writer has found, by actual experiment, that in the stuffing-box on a piston rod 2⅝ in. diameter, the friction required 653 lb. dead weight to pull the rod through the gland, and after the packing was removed, the rod could be turned around with the hand.

Experiment showed that a pressure of 3½ lb. on the low pressure cylinder was necessary to move the piston, which had an area of 201 sq. in., which, as the engine had a constant of 4, gave about 13 hp. required for the friction on the piston rod, or 8 per cent of the rated capacity of the engine.



FIGS. 1 AND 2. CARDS FROM OLD STYLE BROWN ENGINES
FIG. 3. RESULTS OF VALVES HOLDING UP

One bad effect of the tight stuffing-box is the holding up of the exhaust valve, resulting in an apparently excessive back pressure, which will be taken care of by the novice in valve setting by changing the valves.

In several cases, the writer has found the steam valves held up by tight stuffing-boxes, letting the steam blow through and out of the exhaust head 50 ft. into the air. A particular type which is liable to mix up in this way is the old style Brown engine, from one of which I got, on taking charge, a card like Fig. 1, on another, a card like Fig. 2.

In some cases, the cylinder oil may cause the valves to hold up, that is, to stay open after released by the trip motion, instead of being closed by the dashpot, because the oil does not give sufficient lubrication, and in cases of gridiron valves with large bearing surface, if the cylinder oil is not right and the stuffing-boxes are tight, the dashpots may not close the valves.

I have seen a Putnam engine nearly an hour late in starting because the exhaust valve held up on one end, making it impossible to get pressure, all caused by the stuffing-box gland being too tight, and in a Rollins engine, which was in first-class condition, a steam valve was held up by a tight stuffing-box, but this was laid to air bound dashpots until, after an investigation lasting a whole day, the real cause was located.

An idea of the effect of holding up valves by the stuffing-box may be had from the diagrams on Fig. 3, which were taken while stuffing-box trouble was taking place.

It would be interesting if some engineer who has the opportunity, would try the effect, testing either by dead weight or steam pressure required to overcome the gripping effect of packings with different degrees of tightness, and to give us results as thus found.

A. C. WALDRON.

A Practical Oil Extractor

AS ONE travels about and visits various power and electrical plants he notices many novel ways of doing things.

The various devices for saving oil are interesting. If the management will allow it, any of the oil extractors or waste cleaners are good investments for fair sized plants. Engineers in small city plants usually find it rather difficult to get such equipment; then the engineer has the choice of allowing oil and waste used in wiping the oil from the machines to become a dead loss or of running with dirty machines without using any waste for cleaning or of arranging his own cleaning and oil saving device.

This is especially true in the smaller electric lighting plants. When I visited one of these a few days ago, I noticed at once that the engines and generators were wiped clean and dry. Everything about the plant was clean and "ship-shape." The conditions were a little unusual and attracted my attention.

Among other things I noticed an ordinary sausage filling machine. It was just such a machine as you may see in any hardware store in the country towns and was fastened securely to a small bench. I asked the engineer the use of the machine. He demonstrated it at once. Picking up a lot of oily waste from a pail, he filled the chamber of the machine. Then he put on the pressure and squeezed out nearly a quart of good oil, which he dumped into the filtering oiling system. Of course, the waste was not absolutely dry and clean, as it would be if cleaned in a commercial machine; but it was in fine condition for cleaning generators, engines and metal surfaces. Moreover, considerable oil was saved and in condition for use in the oiling system. C. V. HULL.

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Proper Care of Steam Hose

KINDLY GIVE me some information relative to the proper care of steam hose. SUBSCRIBER.

A. The average man who has to use steam hose is perhaps more careless, or rather, thoughtless, regarding the care of it than he might be. The life of steam hose would be greatly prolonged were the users to exercise ordinary common sense in using it and taking care of it when not in use.

Where a steam hose is used in connection with some soot blowing device around boilers, many times the pipe connection is not close enough to the work, and the hose is pulled until it kinks at the nipple where it is attached to the pipe, thus separating the layers and causing a leak. Frequently where the steam does not blow through at once, it works down between 2 layers, rendering the hose useless, as a rupture of this kind usually runs along the hose for several feet, finally breaking through.

The pipe connection should be near enough to the work so that there would be no necessity to kink the hose at the nipples, and in some cases, it might be well to have the nipple drop from a horizontal pipe on a 45-deg. connection.

It is seldom that a steam hose is properly laid away after use. All too frequently it is hung up on a peg or over the edge of a board where its weight will kink it at the place of contact. Many times it is allowed to lie on the floor to be subjected to passing traffic and walked on or even crushed by trucks or wheelbarrows.

Occasionally steam hose used to blow tubes of vertical water-tube boilers with an extension furnace, is allowed to remain on top of the furnace on the hot metal or brickwork, and become overheated, which soon weakens the hose.

Before attaching a hose to a pipe connection, the pipe should be blown out so as to remove all water, thus insuring practically dry steam through the hose as soon as the valve is opened. The valve should be opened slowly so as to permit the hose to warm up gradually, the same as would be done in turning steam into a header or other pipe.

After using, it should not be left connected to the pipe even if it be coiled properly upon a suitable hanger, for the steam left in the hose will condense and settle in the lowest part of the coils to the detriment of the hose. This condensation will be added to in most cases by a leaky valve, and if the hose be kinked over a board or peg, the water will soon find its way in between the layers of the hose and render it useless in a short time.

When through using a steam hose, it should at once be shut off at the valve and disconnected, allowing it to remain in some place under ordinary temperature where it can drain properly, after which it should be neatly coiled on a suitable rack where it will be out of the way and not subjected to an accumulation of dirt.

A good rack for a hose, and one that can be made around almost every power house, can be made quickly by sawing off a foot or so of a common oil barrel. Drive the hoops on well and anchor them with small nails, after which, by boring a couple of holes through the bottom of the barrel, it can be fastened to the wall by bolts or lag-screws screwed into metal anchors, whichever will best fulfill the conditions. G. H. WALLACE.

Operation of Ice Machines

KINDLY TELL me how to start and stop an ice machine.

(2) How do you calculate the horsepower of a steam engine? W. M. T.

ANSWERS

IN STARTING an ice machine, the first thing is to be sure that the discharge valves between the compressor and the condenser are wide open. If a steam driven machine, the discharge valve should be opened even before warming up the engine. Let the machine run slow while opening the suction valve, to guard against accident caused by liquid in the suction line. After suction valve is wide open and everything clear, put the machine up to speed.

It is always best to turn the water on the condenser before starting the machine, but this is not absolutely necessary. If the weather is cold, the water can be left shut off till the machine has run a short time, and the condenser pressure is at its usual point. The only objection to this is, that something may cause the engineer to forget it and perhaps cause an accident.

After the machine is in operation, and the water running over the condenser, the back pressure gage is watched till it shows the desired pressure. Then the expansion valve is opened the required amount.

When shutting down the ice machine, the first thing to do is to pump down the system by shutting the main liquid valve at the receiver, or shutting the expansion valves. Let the machine run till the back pressure gage shows a little above zero, then shut down and close the suction and discharge valves. Some engineers do not shut the discharge valve at all, except when doing repairs on the compressor, or packing the rod. It is best always to shut it, as this will prevent liquid from collecting in the cylinder if the compressor valves leak. Shut the water off the condenser last.

2. To figure the horsepower of an engine, it is first necessary to take indicator diagrams, or draw a theoretical diagram, so that the mean effective pressure on the piston can be obtained.

Multiply the mean effective pressure by the area of the piston, in square inches; by the length of the stroke, in feet, and by the number of strokes per minute. Divide by 33,000 and the result is the horsepower.

The friction load is figured separately from a friction card taken at no load, and is subtracted from the full load horsepower; the result is the horsepower required to do the effective work. Friction may be estimated at 10 per cent of the rated horsepower.

A. G. SOLOMON.

Barometer Readings

WITH A barometer reading of 29 in. and the mercury column registering 27.4 in. vacuum, what is the true vacuum and how obtained? M. W. C.

A. In regard to the barometer pressure, the indication of a mercury U-tube, or gage graduated, to read in inches of mercury, is on the basis of 0.491 lb. for each inch of mercury.

A 29-in. barometer would, therefore, indicate 29 times 0.491 or 14.22 lb. as atmospheric pressure. Your reading of 27.4 in. of vacuum would be 27.4 times 0.491 or 13.45 lb. vacuum. Subtracting this from the atmospheric pressure gives 0.77 lb. as the absolute pressure in the condenser.

Thirty inches barometer pressure is equivalent to 14.7 lb., and subtracting from this 0.77 lb., would give 13.93 lb. vacuum as the equivalent to that which you would have if the barometer reading had been 30 in. instead of 29 in. Dividing this 13.93 by 0.491 gives 28.35 in. vacuum as referred to a 30-in. barometer.

As a matter of practical computation, we could have gotten the same result in this way: 29 minus 27.4 gives 1.6, which subtracted from 30 gives 28.4 as the barometer reading referred to 30 in., which is, for all practical purposes, the same as the value secured in the other way.

A. L. R.

Engine Questions

WHAT WOULD be the pressure at the end of each stroke in the cylinder of a high-speed engine having an automatic governor controlling a single valve cutting off at from ¼ to ¾ stroke?

2. What changes would become necessary on a single eccentric Corliss engine cutting off at from ¼ to ½ stroke if you desired to have this engine carry a heavier load?

3. What were the average cylinder dimensions and rates of speed of simple Corliss engines rated at from 400 to 500 hp. and built about 25 or 30 yr. ago? What were the average main dimensions of return tubular boilers rated at from 150 to 250 hp. built about 25 to 30 yr. ago? F. Mc. I.

ANSWERS

IN ANY kind of engine, the terminal pressure is the pressure in the cylinder at the end of the stroke, assuming that cutoff does not occur until the piston has reached the end of the stroke, and it can be located on an indicator card taken off the engine, completing the expansion curve to the end of the card by means of a pencil.

The terminal pressure is theoretically found by dividing the pressure at the point of cutoff (absolute) by the ratio of expansion. Suppose that cutoff occurs at ¼ stroke as suggested in your inquiry; then the ratio of expansion would be 4.

Let us assume that the gage pressure is 110 lb. Then the absolute pressure will be 125 lb., and this divided by 4, the ratio of expansion, will give 31 lb. absolute, as the terminal pressure. Deduct 15 lb. from this and it leaves 16 lb. terminal pressure, as shown by a gage.

Of course, the later the point of cutoff, the smaller the ratio of expansion, and consequently the larger the terminal pressure. Thus, with a cutoff at ¾ stroke, the ratio of expansion would be 1.33. With a boiler pressure of 120 lb., this would give a terminal pressure of 86 lb., which is so high as to be wasteful. Many engines operate with an initial pressure even lower than this and the initial pressure in the low pressure of the ordinary compound engines, as usually encountered in stationary practice, is seldom more than half this amount.

2. Provided that the engine is designed to withstand the extra strain, there are 2 methods of increasing its capacity so that it will carry more load, one by increasing the initial pressure and the other by increasing the speed.

There are limitations to both of these which must be governed by local conditions. If an engine is direct-connected to a piece of machinery which must revolve at a constant speed, such as a generator, or a lineshaft, it is not practical to increase the speed. The only remedy in this case is to increase the initial pressure.

Frequently it happens that it is desired to increase the capacity of an engine which was made a number of years ago in the days when pressures were comparatively low. While the engine might stand a slightly higher rotative speed, it might not stand an increase in steam pressure, owing to light design. Possibly the initial pressure may already be much higher than that for which the engine was originally designed.

3. The probable size of a Corliss engine of about 30 yr. ago is, at best, but problematical, owing to the general lack of any form of standards; for in those days, while the stroke was, as a general thing, usually about twice the diameter of the cylinder, yet it did not run in multiples of 6, as is the almost universal practice among Corliss engine builders at the present time, such as 36, 42, 48, 54-in., etc. Steam pressures varied greatly, also, so that I can give only an approximate answer; however, I append a table with the sizes of Corliss engines within the range of your inquiry.

Cyl. dimen.	Cutoff	Steam pres., lb.	R.P.M.	I.HP.
20 by 60 in.	1-3	100	65	407
22 " 60	1-4	100	65	404
24 " 52	1-4	90	75	400
24 " 52	1-3	90	75	490
24 " 52	1-4.	100	75	450
24 " 52	1-3	100	75	550
26 " 54	1-5	90	70	404
26 " 54	1-4	90	70	455
26 " 60	1-5	90	65	418
26 " 54	1-4	90	65	502

Speeds as a general thing, however, usually ran about 5 to 15 r.p.m. less than listed above, and the steam pressure in many instances was not to exceed 80 lb. gage.

As boiler horsepower is rated, boilers of the return tubular type of large capacity were not built until within the last few years owing perhaps to the lack of demand for return tubular boilers of 200 rated hp. or over, and partly because there was no standard to go by, and the efficiency of the joints was comparatively low owing to the fact that while the size and quality of rivets were ample, they were pitched so close as to reduce the sectional area of the ligaments between the rivet holes.

The butt strap joint had not come into vogue at that time, and there seemed to be a prejudice against the thicker sheets that were necessary to construct a return tubular boiler of that size. I append herewith a list of the general dimensions as used on 150 and 175-hp. return tubular boilers respectively, of the double riveted lap-jointed type suitable to carry 100 lb. of pressure.

Specifications	150 Hp.	175 Hp.
Diameter of shell in inches	72	78
Tubes, diameter in inches and length, ft.	4 by 18	4 by 18
Tubes, number	72	90
Stack	36 in. by 50 ft.	40 in. by 60 ft.
Thickness of shell in inches	3/8	1/2
Thickness of heads	1/2	9/16
Grates, length in feet	5	5½
Grates, width in inches	72	78
Grates, surface in square feet	30	39
Heating surface in square feet	1584	1868
Diameter lever safety valve, in inches	5	6

GEO. H. WALLACE.

Oak Sawdust for Boilers

I WOULD like a little information regarding the action of green oak sawdust on the inner plates of boilers. Is the use of this injurious?

I have charge of 4 150-hp. return tubular boilers on which I tried out the boiling out process for the removal of scale, but with unsatisfactory results. I used 600 lb. of soda ash and obtained but 128 lb. of scale, so tried the sawdust method which I have found very successful. I have not completed my cleaning, but judge from the size of the pile in the bottom of the shell that I will get about 500 lb. of scale. T. S.

A. In regard to the matter of using green oak sawdust in your boiler, probably it will do no harm, particularly, to use this once; but it would not be a good plan to use it continuously. The substance in the oak which helps to take off the boiler scale is the tannic acid, which works in between the scale and the iron and cuts the film adhering to the iron or steel. The acid will not be very strong, but if the treatment were used repeatedly without the boiler being cleaned out, you would get, in course of time, a solution of acid sufficiently strong to corrode the seams, and any points where there might be pitting in the plates.

Probably the trouble with the boiling out process and use of soda ash is, that the scale is so hard and so firmly attached to the plates, that the soda ash cannot get into the seams.

We would suggest your taking up this matter with a chemist if the oak sawdust treatment does not prove successful at all times. A. L. R.

Electrostatic Capacity of Line Wires

I NOTE a formula for the electrostatic capacity of a single conductor as follows:

$$\text{C, per mile} = \frac{0.0388 \times l}{\log_{10}\left(\frac{4h}{d}\right)} \text{ microfarads}$$

Where l is expressed in miles and h and d in like units if inches, feet or yards.

Kindly explain in full how the above formula may be used. J. B. D.

A. This is used exactly as the formula shows. In the formula as you have given it, you substitute for l, the length of the wire in miles; for h, the height of the wire from the ground, and for d, the diameter of the wire, both h and d being in the same units.

The expression as it is written, signifies the common logarithm of the ratio of 4h to d. The logarithm of 10 is one, but the expression as it is written signifies the logarithm to the base 10 of the quantity in the parenthesis.

The method of finding this would be to divide 4h by d, and then hunt up the logarithm of this quotient in a table of logarithms, or you could take the logarithm of h and the logarithm of 4 from the table of logarithms, and add these together, and subtract from this the logarithm of d. The remainder would be the logarithm to the base 10 of the quantity in parenthesis. You then divide the numerator by the value of this logarithm; not by the number of which it is the logarithm, but the logarithm itself, and the result is the capacity of the overhead line in microfarads. A. L. R.

Increase of Horsepower Due to Condenser

I WISH to know whether or not the addition of a condenser will increase the horsepower of a steam engine.

An engine of 500 hp. is pulling its full capacity noncondensing when the addition of another machine slows the engine down, causing the voltage to drop. We find by adding a condenser that the engine will carry the increased load.

Does the addition of the condenser increase the horsepower of the engine or only its efficiency? R. J. E.

A. As a matter of fact, the addition of the condenser to an engine will increase both the indicated horsepower of the engine and the efficiency. If the condenser pumps be operated from the engine, the net power delivered by the engine will not be increased so much as the indicated power, because the engine would have to furnish power to drive these pumps. If the pumps are separately driven by steam, then the engine will deliver extra power, about in proportion to the indicated horsepower increase.

As an estimate, the steam required by pumps for circulating cooling water, taking out the dry gases, and removing the condensed steam, amounts to about 2.6 per cent of the total steam. For an engine with 5 per cent clearance, running on 120 lb. pressure, with a vacuum of 26 in., the power gained by condensing over noncondensing, with cutoff at 1/3 stroke, is 15.5 per cent, so that you would have a net gain of 13 per cent in the power delivered, for the same amount of steam.

A. L. R.

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Your Winter Study Course

As the long evenings of winter approach and the comforts of living room or study attract you more than exercise in the open air, you will find the greatest enjoyment and most profitable employment in the systematic study of some subject pertaining to your work.

No matter what your position in the plant, there is always room for improving your ability in that work. If you feel that your are not as familiar with one phase of your work as with the others, that is the subject to bring to perfection this winter.

In planning your course of study do not try to cover too much ground. Such a course will lead to a general knowledge only and get you into the mental habit of skimming the surface without getting the real fruit of your work which is a definite, thorough, working knowledge of the subject. Set aside certain evenings of each week for your study and lay out a definite amount of ground to be covered each week.

As an example, take the subject of lubrication. The reason for lubricating is friction, so study the laws governing friction, types of bearings and bearing metals. Then study lubricating materials, such as oil, grease, graphite and mica. Each material should be studied from its origin through its manufacture and methods of testing, both physically and chemically. Each surface lubricated has certain requirements; determine what lubricating qualities are needed for bearings in your plant, and learn to specify the correct lubricant. Take next the means employed for applying lubricants, the handling of oil in the plant, oiling systems, purification and re-use of oil. Study how to economize on oil in your plant, not only economy of oil itself, but to select oil of a quality that gives best results at lowest cost. Hot boxes come next; study their causes and how to treat them so as to bring the bearing back to good condition without a shutdown.

When you have gone over the ground, make an outline of the course you have studied and following this, review the course thoroughly, making sure that all points are clearly understood.

Supplementing the course, it would help to impress the subject more clearly upon the mind if you try experiments in your plant as they are suggested by your reading, and determine the results.

Such a course covers more than can be put into a text book and to get the information you may want will involve considerable research in a good public library, or if that is not available look over the files of your magazines and select from the books reviewed there those which treat subjects you desire to study. Commercial apparatus is best studied from the catalogs of the makers which can nearly always be secured by writing to manufacturers.

Plan your course early, follow it consistently with a concentrated mind and, if the plan is new to you, you will be surprised at the end of the course to find how much you have accomplished during time that is wasted by the majority of men and the degree of expertness you will have acquired if you put into practice the things you have learned from your reading.

Start now. Practical Engineer will be glad to lay out a course of reading on any power plant subject for anybody desiring such directions.

Preparing for Winter

Many power plants used only to furnish heat and light, are found to be out of commission during the summer months. While in the majority of cases engineers in charge of such plants take advantage of the opportunity thus offered and make thorough inspections of their equipment followed up by the required repairs and improvements, others fail to carry on such work, due either to neglect or inability on account of being given other work.

With such practice the plant runs from year to year no attention being given boilers, engines, pumps or other machinery until, as is too often the case, a shutdown occurs, crippling the service and resulting in irreparable damage to the reputation of both engineer and plant.

Officially, summer is still with us, and will continue to be for at least one more month, so that in spite of the occasionally cool and gradually shortening days there is still time to go over things and make the necessary repairs which, while not insuring any plant against breakdown, will go a long way to reduce such possibility to a minimum.

Certainly, no engineer worthy of the name, shut down his plant last spring without taking all necessary precautions to avoid damage to any of his equipment, due to standing idle. Even though he has done so and may feel he can raise steam and turn on the lights within a few hours' notice, he owes it to himself and his plant to go carefully over every pump, every foot of piping, each fitting, every boiler and engine, and all of the electrical equipment to make himself doubly sure that he can give satisfactory and continuous service for the next 9 months.

If you cannot recall which of the valves were leaking just before you shut down for the summer, which of the traps failed to operate properly, which boiler did not appear to be able to carry all of the load you considered it capable of carrying, where the engines pounded most or any of a dozen or more irregularities, try your plant out now—today.

Inspect your boilers well, both externally and internally. Examine all your pipe lines and fittings and see to it that all valves are well packed and that no part of your machinery has been allowed to become rusted or gummed up. Close your boilers, fill with water, and if possible give each a hydrostatic test under a pressure of one and a half times that maintained under regular operating conditions. Having done this, and after blowing down to the proper level, start a slow fire on your grates or stokers, allowing the pressure to rise gradually to the working valve, having, of course, when carrying on the regular inspection, made sure that the safety valves were in an operative condition and set to release at the required pressure.

The initial filling of the boilers must, of necessity, have been done by a hand power or electrically driven pump, or perhaps by water taken from the local water mains. Blow down your boilers to about the first gage. Start your pumps and injectors to see that your feeding apparatus is all right. If the boilers are equipped with some form of automatic feed device this should also be tested.

If time permits, it is well to open the engines, examining the cylinders, pistons, rods, valves, valve chambers and other parts to make sure that they are not rusted or otherwise damaged, and if rusty or dirty, clean well, after which oil all working surfaces with a high-grade cylinder oil. Then turn your attention to other parts of the engines, such as the bearings, guides and other working surfaces, giving them the same treatment as the cylinder.

See that all valve stems are repacked, as it is more than likely the old packing, after having been out of use for such a long time is hard and worthless.

All modern generators are equipped with ring oilers which carry the oil from a reservoir below the bearings above. Regardless of precautions taken considerable dust and grit will find its way into this oil, rendering it anything but desirable for lubricating purposes. It is, therefore, advisable, whether or not a great amount of this dirt be found at the bottom of the reservoir, to remove all of the contents, cleaning the well thoroughly with kerosene and refilling with new oil.

Examine the brushes and commutator carefully to see that these are in good order.

The unit or units may then be slowly started and run at a reduced speed for an hour or so during which time pay close attention to all bearings to see that these are not heating. Gradually increase the speed, running the engine idle for some time with open throttle.

Build up the voltage of the generator, noting whether any sparking occurs at the commutator. Having satisfied yourself that so far all is well, the load may now be put on.

Having assured yourself that all parts of the boilers, pumps, injectors, piping, auxiliary apparatus and generating units are O. K. attention may now be turned to the heating system.

Within a few weeks the demand for heat will be continuous and any interruption of service will be met with complaint from tenants or workmen. If you desire to go through the season without a complaint, now is your last chance to give the heating system the "once over" and put it in shape for a season of continuous use.

The leaks which developed last season should be hunted up and stopped. Inspect the valves to see that they do not stick and are properly packed. Air vents should be adjusted early in the season or considerable steam may be lost. See that the radiators drain properly. Test the back pressure valve to make sure that it will not stick in either closed or open position, do the same to the reducing valve. Examine the oil separator, for radiator surfaces covered with a film of oil cannot give best results. Put the vacuum pumps in first-class condition. Repair all broken insulation.

Some parts of the buildings heated may not have had sufficient radiating surface last year, while others wasted heat through open windows; these conditions should be remedied by shifting radiators. Remember that when you use all your exhaust steam in the heating system over 90 per cent of the heat in your coal is used for heating and small wastes accumulate rapidly.

The heating system is that part of the plant with which everybody connected with the factory comes in contact, and a system which works perfectly is a big advertisement for the engineer in charge.

Power Apparatus in Shop and Market

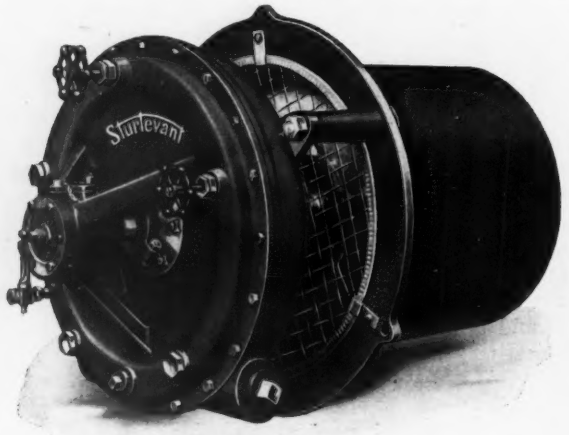
New Ideas In Making, Buying and Selling

Sturtevant Turbo-Undergrate Blower

DEVELOPMENTS in the efficient operation of boilers have proved that heretofore boilers have been worked at considerable lower capacity than is possible for them to develop, which, in many cases, has necessitated the installation of many boilers more than is necessary, except during the peak loads of the day. The reason for this is due largely to the fact that insufficient draft was available from the stacks which serve the boilers, and to remedy this defect, one of the most popular methods is the use of an individual forced draft fan, delivering air beneath the grate of the furnace.

The Sturtevant turbo-undergrate blower is designed for installation in individual boiler settings, and consists of a steam-driven turbine, upon the shaft of which is mounted a fan which is placed in a casing built into the boiler setting.

The casing of the turbine allows a large amount of exhaust space, which eliminates internal back pressure



STURTEVANT TURBO-UNDERGRATE BLOWER.

and tends to improve steam consumption. The steam is directed from nozzles on to the buckets of the rotor, which give the steam a 180-deg. reversal. The steam is returned to the rotor by means of the reverse buckets several times, so that the maximum amount of energy of the steam is converted into work. Reverse buckets on the nozzle have been used to some extent on large turbines, but the Sturtevant is the first turbo-undergrate blower to which this refinement has been applied. These reverse buckets reduce the steam consumption.

The rotor, or bucket wheel, is a solid forging of open hearth steel, with the buckets milled in the rim of the solid metal. The turbines are made with 1, 2, 4, 5 or 6 nozzles, depending on the size of the fan to be driven and the amount of air required. The fireman can shut off one or more nozzles, by closing a hand-operated valve, as the load decreases, thus securing high efficiency and maximum steam economy at partial loads. The set can also be automatically controlled by a regulating valve operated by boiler pressure. The bearings are bronze, oil ring lubricated, and specially designed for severe and continuous service, to which this type of blower is usually subjected.

The fan, which is of the propeller type, consists of 6 drawn aluminum blades, fastened with steel rivets into a bronze head. The blades are stamped out with dies, thus being the exact shape required and always the same.

Some of the exhaust steam from the set is generally allowed to escape into the ash pit to prevent clinkering. Only a small part of the exhaust steam, however, should be used for this purpose, for if all the steam is exhausted under the grate, it is likely to destroy the ironwork in the flues and the stack. The exhaust steam may be used for heating feed water, or in heating and drying systems against a back pressure up to 25 lb. This apparatus is the product of the B. F. Sturtevant Co., Hyde Park, Boston, Mass.

New Pneumatic Drill

OF timely interest to everyone having portable drilling to do, whether in machine shop, boiler shop, engine room, or on structural steel work, is a new pneumatic drill for close-quarter drilling, reaming, tapping, etc. This tool shown in the accompanying illustration is a recent addition to the Little David line of pneumatic tools, manufactured by the Ingersoll-Rand Co., 11 Broadway, New York.

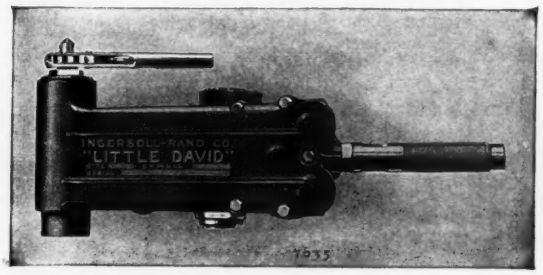
The Little David close-quarter drill is particularly adapted for working in cramped or confined positions, where the regular type of 4-piston, reciprocating pneumatic drill cannot be used, the distance from the end of the casing to the center of the spindle being only 1 5/16 in.

The motor is of a novel 3-cylinder design and operates in a bath of oil. The valve is of the rotary type, a construction which has been featured in all Little David drills, and is gear-driven from the pinion of a 3-way crank shaft which is operated by the 3 ratcheted levers which directly connect the pistons to the drill spindle.

One of the important features of this machine is that there is practically no strain on the crank shaft, as the power is transmitted direct from the pistons through the levers to the ratchet spindle. The spindle has a triple ratchet, and a noteworthy feature is that one of

the ratchets is engaged on the spindle at all times. This construction is claimed by the manufacturer to develop more power and a much more constant pull on the spindle.

The casing is divided in such a way that the loosening of a few cap screws allows easy access to all moving parts.



LITTLE DAVID CLOSE-QUARTER DRILL

The manufacturer claims this drill to be the most powerful tool of its type and size. Owing to its extreme simplicity it is estimated that the Little David close-quarter drill can be dismantled and completely reassembled in 30 min.

It is fitted with a No. 4 Morse taper socket; is rated for drilling up to 3 in. and reaming and tapping to 2 in., and operates at a speed of 150 r.p.m.

Bearings Without Oil

IT is a fact which has been established by careful scientific test, that the use of graphite in connection with lubricating oil materially reduces the friction and lengthens the life of the bearings, and lessens the quantity of oil needed. It has remained for the Graphite Lubricating Co., of Bound Brook, N. J., to establish the possibility of successful operation of bearings without lubricating oil, while, at the same time, producing a bearing which can be used with lubricant, if so desired, to better advantage than the ordinary bearing.

FIG. 1. BOUND BROOK BUSHING FOR "ALL OVER" BEARING

Twenty-five years of experience and experiment lie behind the success of this work. Much depends on the graphite used, and in the Bound Brook graphite bushings, the material is such as the experience of the company has shown to be best fitted for this work. The bearings are made in all sorts of shapes, and for all sorts of purposes, depending on the location where they are to be used, and the service which they must render. The graphite is applied to the inside, to the outside, to the end or to all parts, as may be required. A bushing in which lubrication at all points is necessary, is shown in Fig. 1, indicating the method of combining the graphite insets with the bronze body of the bushing. The graphite and bronze surface are flush, wear evenly, and require no refilling, and will run entirely without oil, although the application of oil does no harm. Figure 2 shows smaller bushings of special shapes, with the inside graphite grooves only. These bushings are made in all sizes, from the smallest high speed spindles in cotton mills and turbines up to bushings for propeller shafts in battleships.

FIG. 2. FORMS OF GRAPHITE JOURNAL BEARINGS

Another type of oilless bearing is the Nigrum wood bearing, impregnated with graphite. These are specially adapted to places where dust and grit may accumulate and follow the oil around the bearing. As the wood bearing is softer than the shaft, these particles of dust and grit will become imbedded in the wood, and will, therefore, not coat the metal of the shaft. Three types of the Nigrum bearings are shown in Fig. 3, illustrating the different ways in which they are fashioned for different uses. Like the graphited bearings, these may be run without any oil, and will work perfectly, but the use of oil, if desired, will do no harm.

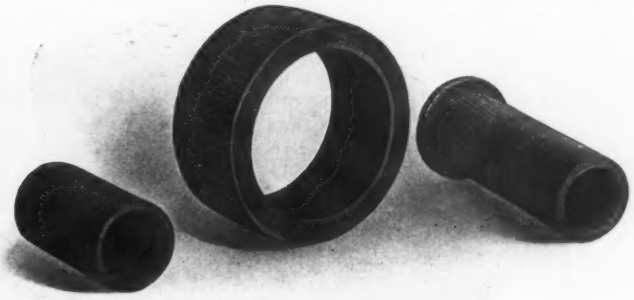


FIG. 3. NIGRUM GRAPHITE-IMPREGNATED WOOD BEARINGS

Cochrane Recorder for Flow over Weirs

WITH any type of weir or orifice, the rate of flow is dependent upon the head, and once the law of the weir or orifice is known, may be calculated directly therefrom. For most purposes of measurement, however, mere knowledge of the rate of flow at a given instant is not sufficient, but continuous or total results are wanted. This has led to the development of various types of flow recorders, one of the most recent of which is illustrated herewith.

Figure 1 is designed to illustrate the principle and essential elements of such recorders. First there is a float which moves vertically in response to changes in head. With weirs or orifices where there is a free surface of the liquid on the up-stream side, this float rests directly on the surface, whereas with Pitot tubes and Venturi tubes, it ordinarily rests upon the surface of mercury in one of the legs of a U-tube, the 2 ends of which are subject to the differential pressure due to the Venturi or Pitot tube.

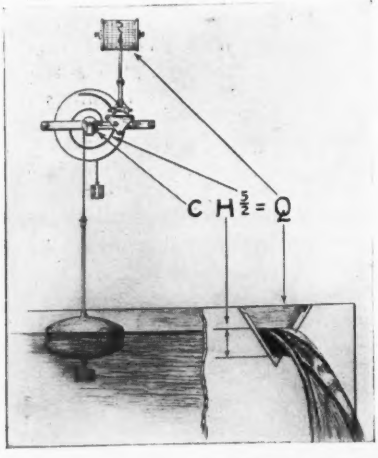


FIG. 1. DIAGRAM SHOWING PRINCIPLE OF COCHRANE RECORDER

If the motion of the float is employed directly to actuate the recording device, so that the motion of the recording pen is directly as the motion of the float, or in proportion to it, a record of rate of flow can be obtained, but the divisions on the chart are not in general equal for equal increments in rate of flow. It is therefore necessary to incorporate some kind of modifying mechanism, ordinarily a cam, between the motion of the float and the motion of the recording pen.

Besides taking account of the law of flow over the weir, the mechanism must also provide the proper ratio between float movement and pen movement. The maximum float movement may, for instance, be 4 or 10 in., whereas, the maximum pen movement, that is, the maximum height of chart, may be 2.5 in. Flow of water over a V-notch varies as the 5/2 power of the head, and, if the cam for use with a V-notch were of the same length as the maximum movement of the float, it would have a very steep rise at the end corresponding to the high heads, which would give rise to binding between the surface of the cam and the cam follower. In the design of recorders for use with V-notch and rectangular weirs, it is customary, therefore, to make the total length of the cam much greater than the movement of the float, using a multiplying gearing between the float stem and the cam.

In the flow recorder here described, the cam is laid out as a spiral on a flat circular plate, and the multiplying mechanism consists of a small drum mounted upon the spindle of the cam, and having wrapped about it a thin metal cable which is attached to the float spindle, a counterweight on another cable serving to keep the first cable taut. The spiral groove is cut into the surface of the disk, and is so arranged that the part of the cam corresponding to low heads is near the center of the disk, and the part corresponding to high heads is near the periphery of the disk, so that what would otherwise be the steeper part of the cam is at the greater radius. To accommodate the recorder for use with weirs of different heights, it is only necessary to substitute cable drums of the proper respective diameters. One cam serves for all weirs, having the same law connecting head and flow; hence, it has been commercially feasible to devote considerable expense to the mechanical means of reproducing this cam in order to insure accuracy.

Elimination of friction and back-lash is a prime requisite in the design of such apparatus. In the present case, back-lash has been eliminated by the use of a cable drum instead of the gear and pinion drive formerly employed, while friction has been reduced as much as possible by mounting the spindle of the cam upon anti-friction rollers. Accuracy is also promoted by the use of a large, powerful float, and where an enclosed weir chamber is employed, and the float stem must pass through a packing gland, the latter should be of the self-alining type. By using a slender stem, the harmful effects of errors in alinement are reduced, and the cross-sectional area upon which any pressure which may exist within the float chamber may act in tending to force the stem out of the chamber is minimized.

The pen carriage is provided with large rollers or wheels, which rest upon horizontal ways, so that the cam follower which is attached to the pen carriage moves diametrically to the cam disk. The construction is such that the cam follower cannot be accidentally displaced from the cam slot.

The pen is suspended from the pen carriage in such manner that it rests lightly against the chart drum by gravity, and can readily be removed for cleaning of the pen or while the chart is being renewed. The direction of motion of the chart drum is such that the progress of the pen is from left to right when the chart is held with the bottom toward the observer.

As the chart is driven uniformly by a clock, the pen not only records the rate of flow at each instant, but the area under the pen-trace is proportional to the total flow for any elapsed period. In other words, the user of this recorder is supplied not only with a history of the rate of flow, as for instance the rate at which his boilers have been fed throughout the day, but may also obtain by the use of an ordinary engine planimeter the total amount of water which has been fed to the boilers,

and by comparing this quantity with the amount of coal used, may determine the total and average evaporation for the day.

Many users, however, desire to obtain the total flow directly, without the use of a planimeter, and for this purpose an integrating attachment has been added. This consists of a counting-train likewise suspended from the pen carriage, and driven by a small roller which rests upon an aluminum clock-driven disk. When the float and cam are at the position corresponding to the zero head, this roller is at the center of the disk, hence receives no motion from the rotation of the latter. As the pen carriage is moved away from the zero position, the small roller is carried the same distance away from the center of the aluminum disk, and is driven at a rate corresponding to the rate of flow over the weir. The total movement of the counting train will therefore correspond to the total flow.

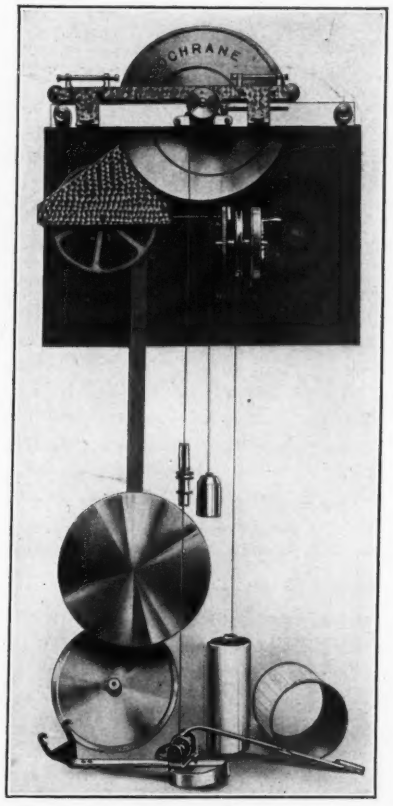


FIG. 2. COCHRANE RECORDER REMOVED FROM CASING, WITH CHART DRUM AND PEN AND INTEGRATOR REMOVED TO SHOW ELEMENTS OF CLOCK MOVEMENT

To meet a third requirement, a visible pointer moving along a large scale with open divisions has been added, making it possible to read the rate of flow from a distance.

All parts of the mechanism of this recorder are made to accurate dimensions by means of templates and limit gages, the cam for instance being cut by an automatic machine to correspond to a master cam made of hardened steel. To be sure of the accuracy of the instrument, therefore, it is only necessary to know that it is properly adjusted, that is, when the float is at zero position; in other words, when the level of the water upon which it rests is at the zero level of the weir, the cam must be at zero position, the pen on the zero line of the chart, and the integrator roller at the center of the aluminum disk. This adjustment, particularly the adjustment of the cam to zero position, should be carried out while the entire apparatus is under working conditions, in order that contraction and expansion may be allowed for.

The method of adjustment is as follows. Water is first drawn down to zero level, as indicated by a hook-gage, usually attached to the outside of the weir tank. When this has been done, a micrometer screw at the point of attachment of the cable to the float stem is manipulated until a zero mark on the cam stands opposite a fixed pointer. The cam is then locked in zero position by means of a pin, after which the pen is brought to the zero line of the chart by a micrometer adjustment on the pen suspension, and a similar adjustment is used for setting the integrator roller to the center of the aluminum disk.

The time-keeping qualities of the clock or clocks which drive the chart drum and the integrator disk are of equal importance with accuracy on the part of the flow-translating mechanism, since if the clock runs too fast or too slow, the total as indicated by integrating the chart or by reading the counting train will be correspondingly too large or too small. The chart drum ordinarily revolves once in 24 hr. although more rapid motion is used where changes in rate of flow are rapid and frequent and an open chart is desired. For securing a good degree of accuracy with the counting train, the aluminum disk should revolve once in about 15 min. Heretofore it has been customary to drive the chart drum and the integrating train by separate clocks, employing for the chart especially designed hair-spring escapement movements imported from Germany, and for the aluminum disk commercial hair-spring escapement movements of the 8-day pattern. This, however, involves not only the winding, setting and regulating of 2 separate clocks, but the commercial movements were not originally designed, and are not altogether best adapted, for the service, and to secure the desired rates of revolution, particularly for the integrating disk, supplementary gears must be attached. Eight-day movements furthermore have no particular advantage in service of this kind, where the chart must be renewed daily, as they give rise to uncertainty as to whether the clock has been wound or needs winding, whereas, if the clock is wound daily, when the chart is renewed, it becomes habitual routine, and is not neglected. At the same time, the clock should be able to run over holidays and Sundays on one winding.

In the present instrument, only one clock is employed, a powerful, weight-operated pendulum movement, making 80 beats a minute. Furthermore, by arranging the parts in the proper order, it has been possible to attach both chart drum and integrator disk directly to spindles of the clock train. The heavy propelling weight is suspended by a cable which winds over a drum, the spindle of which also carries the chart drum. This spindle is directly supported by ample bearings on either side of the cable drum, and is connected by a flexible coupling

to the first shaft of the clock movement. Inasmuch as the chart drum makes one revolution in 24 hr., this is the speed of rotation of the cable drum, which is of such diameter that the clock weight will fall a little less than half the height of the recorder casing in that time. When the record drum is removed, a handle is exposed, by means of which the clock may be wound, the intention being that the operator shall wind the clock for a day's run when changing records, thus making it a regular routine. The weight used is of the size ordinarily used for 8-day clocks, 6 lb., and as it expends its entire energy in 2 days instead of 8 days, the clock movement has exceptional power.

The clock spindle which revolves with the weight drum, carries at its other end a gear meshing with a pinion on the spindle of the integrator disk, the motion thus being transmitted directly. The integrator disk

FIG. 3. COCHRANE RECORDER COMPLETE IN DUST-PROOF CASE

is on a level with the chart drum, so that the 2 are side by side, symmetrically placed in the casing, and at all times visible through the door, as may be seen from Fig. 3. A gear on the spindle of the integrator disk drives an intermediate pinion on the spindle of a gear which drives the escapement, giving altogether only 3 gear reductions from driving weight to pendulum. The gears and pinions and spindle bearings are extra heavy and of large area, while the escapement is of the Graham dead-beat type. As the pendulum is pivoted to swing in both directions, it serves as a plumb-bob in lining up the case.

Clock and recorder parts are supported from brackets on a cast-iron base which is attached to the backplate of the case, the latter being built of heavy plate throughout, with a flanged bottom of heavier material than the sides. The door is flanged, is carried on 3 hinges, and is held closed by 3-way draw-in bolts operated from a single lock, with felt gaskets around the door and on both sides of the plate-glass window to prevent the entrance of dust.

The Cochrane flow recorder, while originally designed for use with V-notch weirs, may be used with rectangular weirs or submerged orifices. It is regularly supplied in connection with the Cochrane V-notch meters and metering heaters manufactured by the Harrison Safety Boiler Works, Philadelphia, Pa., which has supplied the information from which this article has been prepared.

News Notes

THE FIRST NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in New York City the week beginning Sept. 20. It will show the advances in chemical art in this country, and will be accompanied by a program of papers for the meeting of the American Chemical Society, covering problems in the operations of chemical works and in the marketing of chemicals.

JOINT MEETING of the American Society of Refrigerating Engineers and American Association of Refrigeration will be held in San Francisco Sept. 21 to 25 at the Exposition Memorial Auditorium. Hotel headquarters will be at Inside Inn, within the grounds of the Panama-Pacific Exposition. Tuesday and Wednesday will be devoted to sightseeing, the first technical session being held on Thursday morning at 9:30, which will take up business matters, appointment of committees, and a paper on "Oil Engine Driven Raw Water Ice Manufacturing," followed by discussion on "Raw Water Ice-Making Systems." The afternoon session at 2 o'clock will take up papers on Refrigeration in France, in Sweden and in the United States. Friday morning papers will be read on "Fruit Pre-Cooling" and description of San Bernadino Precooling Plant, and on "Heat Transfer in Double Pipe Brine Coolers," followed by a discussion on the power required to agitate brine in can ice tanks. The afternoon will be devoted to a visit to the special refrigeration exhibits, and the evening and Saturday will be taken up with excursions and with a final banquet on Saturday evening.

THE GENERAL ELECTRIC Quarter Century Club of the Schenectady works held its first outing Saturday, Aug. 28, the occasion being an excursion to Lake George over the Delaware & Hudson lines by special train, which started from the works, and which connected with the steamer Sagamore at Lake George station. The party had a 70-mi. trip to the Hague on the steamer, dinner being served on board.

As its name implies, the Quarter Century Club is composed of men and women who have been in the service of the company 25 yr. or more.

The officers of the club are: President, A. L. Rohrer; vice-president, John Riddell; secretary, Frank Arthur; treasurer, H. W. Leland; trustees, E. S. Beyer, John Waldron, D. O. Youlen.

Special significance attaches to the fact that the average age of the 206 club members who attended the excursion was 52 yr. The "old fellows" were in the minority as to numbers, if not in years. A fine esprit de corps was apparent throughout the day, which reflected the working strength of the General Electric organization.

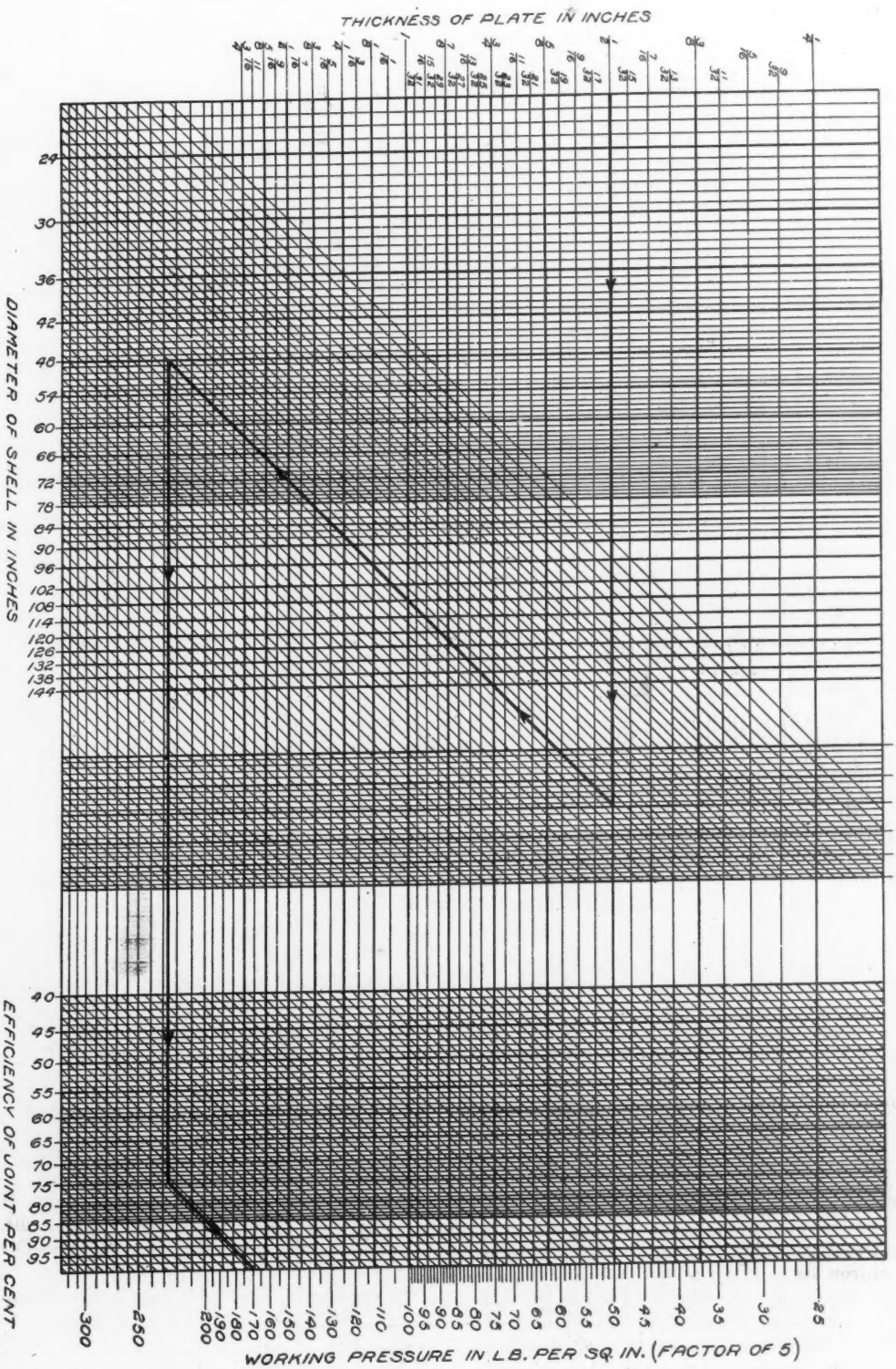
These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit

PRACTICAL ENGINEER

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

C. J. CRAFFEY.

CHART 1. WORKING PRESSURE ON CYLINDRICAL SHELLS



SAFE WORKING PRESSURE ON BOILERS

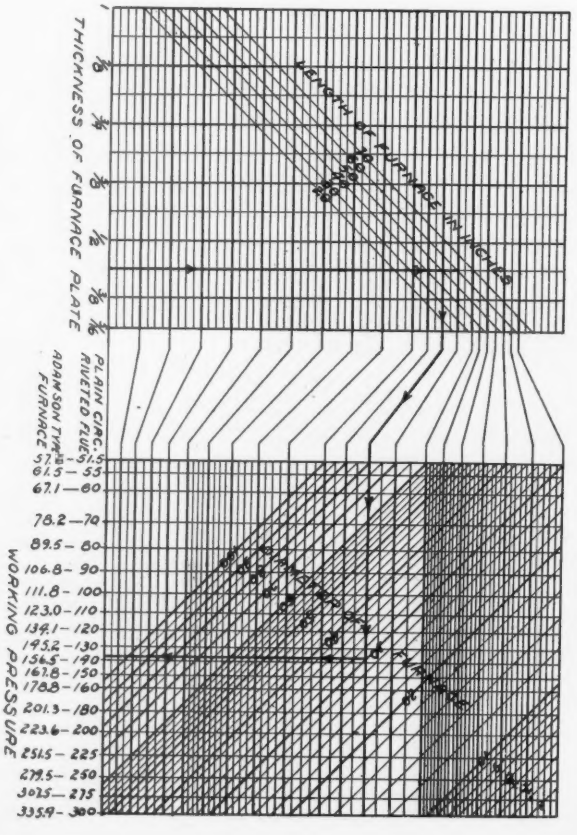
CHART I GIVES a means for determining safe working pressures on the shell of a boiler. Proceed as indicated by the arrows, starting with the proper thickness of plate and turning successively at the tensile strength, diameter of shell, efficiency of joint and ending with the pressure. The accompanying table gives the efficiencies of the best proportioned joints used in power boilers.

Chart II applies to plain circular riveted flues and furnaces made in sections of not less than 18 in. in length and not less than 5/16 in. thick, also to Adamson type furnaces of like dimensions. The arrows show the method of using the chart. For other types of furnaces under collapsing pressure the general formula is:

$$P = \frac{C \times T}{D}$$

In which P = pressure, lb.
T = thickness, in., not less than 5/16 in.
D = mean diameter, in.
C = 17,300 for Leeds suspended bulb type.
= 17,600 for Morrison corrugated type.
= 14,000 for the Fox type.
= 14,000 for the Purves type when D = least outside diameter and thickness not less than 7/16 in.
= 14,000 for the Brown type when D = least outside diameter.
= 10,000 for corrugated furnace in sections not less than 18 in. from center to center and thickness not less than 7/16 in.

CHART II. WORKING PRESSURE ON FURNACES OF INTERNALLY FIRED BOILERS



PITCH AND EFFICIENCY OF STANDARD BUTT AND DOUBLE STRAP JOINTS

THICKNESS OF PLATE	THICKNESS OF INSIDE BUTT STRAP	DIAMETER OF RIVET HOLES	DOUBLE RIVETED T.S. 55000 MOST DESIRABLE PITCH OF RIVETS IN OUTER ROW	DOUBLE RIVETED T.S. 55000 EFFICIENCY OF JOINT	DOUBLE RIVETED T.S. 58000 MOST DESIRABLE PITCH OF RIVETS IN OUTER ROW	DOUBLE RIVETED T.S. 58000 EFFICIENCY OF JOINT	TRIPLE RIVETED T.S. 55000 MOST DESIRABLE PITCH OF RIVETS IN OUTER ROW	TRIPLE RIVETED T.S. 55000 EFFICIENCY OF JOINT	TRIPLE RIVETED T.S. 58000 MOST DESIRABLE PITCH OF RIVETS IN OUTER ROW	TRIPLE RIVETED T.S. 58000 EFFICIENCY OF JOINT	QUADRUPLE RIVETED T.S. 55000 MOST DESIRABLE PITCH OF RIVETS IN OUTER ROW	QUADRUPLE RIVETED T.S. 55000 EFFICIENCY OF JOINT	QUADRUPLE RIVETED T.S. 58000 MOST DESIRABLE PITCH OF RIVETS IN OUTER ROW	QUADRUPLE RIVETED T.S. 58000 EFFICIENCY OF JOINT
1/4	1/4	5/8	3 3/16	83.3	3 3/4	82.5	6 3/16	89.3	5 7/16	88.9				
		11/16	4 3/16	83.3	4	82.8	6 1/2	89.4	6 1/4	89.0				
		3/4	4 1/16	83.6	4 1/16	83.0								
		7/8	4 3/16	83.7	4 1/8	83.0								
5/32	1/4 OR 3/8	5/8	3 3/16	82.7	3 3/16	81.9	6 1/16	89.1	5 7/16	88.7				
		11/16	4 1/16	83.0	3 1/2	82.2	6 1/16	89.3	5 7/16	88.4				
		25/32	4 5/16	83.1	4 1/8	82.4								
		3/4	4 1/2	83.1	4 1/4	82.3								
3/16	1/4	11/16					6	89.0	5 7/16	88.4				
		3/4	4 3/16	82.8	4	82.0	6 1/16	89.0	6	88.5				
		25/32	4 7/16	82.8	4 3/16	82.0	6 1/16	89.1	5 5/8	88.6				
		7/8					6 1/16	88.7	5 5/8	88.6				
3/16	1/4	11/16	4 3/16	82.8	4 3/16	81.8	7 1/16	89.2	6 1/8	88.6				
		3/4	4 3/16	82.7	4 1/8	81.9	7 1/16	89.1	7 1/16	88.6				
	1/4 OR 3/8	25/32	4 1/16	82.8	4	82.0	6 7/8	89.1	6 1/16	88.7				
		7/8	4 3/16	82.8	4 3/16	82.0	7	89.2	6 1/16	88.7				
		29/32	4 5/16	83.1	4 1/16	82.3	7 1/16	89.3	7	88.8				
		15/16	4 7/16	83.3	4 3/16	82.4	7 1/16	89.1	7 1/16	88.8				
7/32	1/4	11/16					5 7/16	88.9	5 3/16	88.3				
		3/4					6 1/16	89.1	5 7/16	88.4				
		13/16	4 1/16	82.3	3 15/16	81.5	6 3/16	89.0	5 7/16	88.5				
		25/32	4 1/16	82.3	4 1/16	81.5	6 3/16	88.8	6 1/16	88.4				
		7/8	4 1/16	82.3	4 1/16	81.6	7 1/16	89.0	6 3/16	88.5				
		29/32	4 1/16	82.4	4 1/16	81.8	7 3/16	89.0	7 1/16	88.4				
	1/4 OR 3/8	3/4	4 1/16	82.3	3 15/16	81.5	6 3/16	89.0	6 1/16	88.5				
		25/32	4 1/16	82.6	4 1/8	81.8	6 3/16	88.8	6 3/16	88.5				
		7/8	4 1/16	82.6	4 3/16	81.8	7 1/16	89.1	6 1/16	88.6				
		29/32	4 3/16	82.6	4 3/16	81.8	7 1/16	89.1	7 1/16	88.6				
		15/16	4 3/16	82.6	4 3/16	82.1	7 1/16	89.1	7 1/16	88.6				
9/32	1/4	11/16	4 1/16	82.3	3 15/16	81.5	7 1/16	88.9	6 3/16	88.3	13 1/8	94.5	12 3/16	94.1
		3/4	4 1/16	82.3	4 1/16	81.5	6 1/16	88.8	6 1/16	88.4	13 3/16	94.5	13 1/16	94.2
		13/16	4 1/16	82.3	4 1/16	81.6	7 1/16	89.0	6 3/16	88.5	14 1/16	94.5	13 3/16	94.3
		25/32	4 1/16	82.4	4 1/16	81.6	7 1/16	89.0	7 1/16	88.5	15	94.5	14 3/16	94.3
		7/8	4 1/16	82.6	4 1/16	82.0								
		29/32	5 1/8	82.8	4 1/8	82.0								
	3/8	15/16					7 3/16	89.1	7 1/16	88.6	13 1/8	94.5	12 15/16	94.4
		1					7 3/16	88.7	7 3/16	88.5	16	94.5	15 1/16	94.4
5/32	3/8	25/32	4 3/8	82.1	4 3/16	81.3	7 1/16	88.9	6 15/16	88.4	14 1/16	94.5	13 1/16	94.2
		13/16	4 3/16	82.1	4 3/16	81.4	7 1/16	88.9	7 1/16	88.4	14 1/16	94.5	14 1/16	94.2
		25/32	4 3/16	82.4	4 3/16	81.5								
		7/8	5	82.5	4 3/16	81.6								
		29/32					7 1/16	89.0	7 3/16	88.5	15 1/16	94.6	14 3/16	94.3
		15/16					7 3/16	88.7	7 3/16	88.5	16	94.5	15 1/16	94.3
7/16	3/8	25/32	4 1/16	82.0	4 1/16	81.2	7 1/16	88.9	7 1/16	88.3	13 15/16	94.5	14 3/16	94.2
		7/8	4 3/16	82.2	4 1/16	81.3	7 1/16	88.7	7 1/16	88.4	16	94.5	15 1/16	94.2
		29/32	5 1/16	82.3	4 3/16	81.6	6 1/16	89.0	7 1/16	88.4	16 1/16	94.5	15 1/16	94.2
		15/16	5 3/16	82.5	5 1/16	81.7	6 3/16	89.0	6 15/16	88.5	16 1/16	94.5	16 1/16	94.3
7/32	3/8	25/32	5 1/16	82.1	4 7/16	81.4	6 3/16	88.9	7 1/16	88.4	16 1/16	94.5	15 3/16	94.2
		13/16	5 1/16	82.1	5 1/16	81.4	6 1/16	88.8	6 15/16	88.4	16 3/16	94.4	16 1/16	94.2
1/2	7/16	29/32	5	81.8	4 7/16	81.1	6 1/16	88.8	7 1/16	88.3	16 3/16	94.4	15 1/16	94.1
		15/16	5 3/16	81.9	5	81.2	6 1/16	88.8	6 1/16	88.3	16 1/16	94.3	16 1/16	94.1
		1	5 1/16	82.1	5 1/16	81.3	6 1/16	88.8	6 1/16	88.4	17 1/16	94.4	16 1/16	94.2
		1 1/16	5 3/16	82.2	5 3/16	81.3	6 1/16	88.4	6 1/16	88.4	17 1/16	94.4	17 1/16	94.2
9/32	7/16	25/32					8 1/16	88.7	7 1/16	87.9	16 1/16	94.3	15 1/16	93.6
		13/16					8 1/16	88.6	8	88.2	16 1/16	94.3	16	94.1
		29/32					6 1/16	88.6	8 1/16	88.3	17 1/16	94.4	16 1/16	94.1
		15/16					8 3/16	88.3	8 1/16	88.3	17 1/16	94.4	17 1/16	94.2
		1					8 1/16	88.3	8 1/16	88.3	17 1/16	94.4	17 1/16	94.2
		1 1/16					8	88.2	8	88.2	18	94.4	18	94.2
5/16	7/16	25/32					8 1/16	88.7	8 1/16	88.0	17 1/16	94.3	16 1/2	93.7
		1					8 1/16	88.6	8 1/16	88.3	18	94.4	17 1/16	94.1
		1 1/16					8 1/16	88.3	8 1/16	88.3	17 3/16	94.1	17 3/16	94.1
		1 1/16					8	88.2	8	88.2	18	94.0	18	94.0
11/32	7/16	25/32					8 1/16	88.5	8 1/16	87.4	17 1/16	94.0	16 1/16	92.6
		13/16					8 1/16	88.5	8 1/16	87.7	17 1/16	94.2	17	93.3
		1					8	88.5	8 1/16	88.1	18	94.3	17 1/16	93.9
		1 1/16					8	88.2	8	88.2	18	94.0	18	94.0
3/8	1/2	1 1/32					8	88.4	8 1/16	87.5	18	94.0	17 1/16	93.0
		1 1/16					8	88.2	8	87.8	18	94.0	18	93.5
7/32	1/2	1 1/32					8	87.8	8 1/16	87.0	18	93.2	17 1/16	92.2
		1 1/16					8	87.8	8	87.2	18	93.5	18	92.6
11/16	1/2 OR 9/16	1 1/16					9 1/16	87.6	8	86.7	18 1/16	92.9	18	91.9
		1 1/16					9 1/16	87.1	9 1/16	86.9	18 1/16	93.5	18 1/16	93.2
25/32	1/2 OR 9/16	1 1/16					9 1/16	86.9	8 15/16	85.9	18 1/16	92.1	17 1/16	91.0
		1 1/16					9 1/16	87.0	9 1/16	86.3	18 1/16	93.4	18 1/16	92.4
3/4	1/2 OR 9/16	1 1/16					8 15/16	86.1	8 15/16	84.3	17 15/16	91.2	16 15/16	90.0
		1 1/16					9 1/16	86.8	9 1/16	86.2	20	93.1	20	92.2
		1 1/16					9 1/16	86.1	9 1/16	86.1	20	93.4	20	93.3
13/16	1/2 OR 9/16	1 1/16					10	87.0	10	86.5	20	92.4	20	91.6
		1 1/16					10	86.9	10	86.2	20	93.5	20	92.5
13/16	1/2 OR 9/16	1 1/16					10	86.8	9 15/16	85.6	20	91.8	19 15/16	90.7
		1 1/16					10	86.4	10	85.8	20	92.2	20	91.8
7/32	5/8	1 1/16					9 15/16	86.0	9 1/16	84.8	19 15/16	91.1	18 3/4	89.8
		1 1/16					10	85.9	10	85.3	20	92.1	20	91.1
7/8	5/8 OR 11/16	1 1/16					9 1/16	85.1	9 1/16	84.0	18	90.2	18 3/4	89.0
		1 1/16					10	85.5	10	84.9	20	91.4	20	90.5
		1 1/16					10	85.4	10	84.6	20	92.4	20	91.4
29/32	5/8 OR 11/16	1 1/16					9 1/16	84.4	8 15/16	83.3	18 1/16	89.4	17 15/16	88.2
		1 1/16					10	85.1	10	84.5	20 1/16	91.0	20 1/16	90.2
		1 1/16					10	84.9	10	84.2	20 1/16	91.9	20 1/16	90.9
15/16	5/8 OR 11/16	1 1/16					9 1/16	83.7	8 15/16	82.5	18 1/16	88.7	17 15/16	87.4
		1 1/16					10 1/16	85.1	10 1/16	84.5	20 1/16	90.5	20 1/16	89.8
		1 1/16					10 1/16	84.8	10 1/16	84.1	20 1/16	91.3	20 1/16	90.2
31/32	11/16 OR 3/4	1 1/16					10 1/16	85.1	10 1/16	84.0	21	90.2	20 1/16	89.0
		1 1/16					10 1/16	84.8	10 1/16	84.1	21	90.6	21	89.9
1	3/4	1 1/16					10 1/16	84.4	9 15/16	83.3	20 1/16	89.5	19 1/16	88.3
		1 1/16					10 1/16	84.4	10 1/16	83.6	21	90.3	21	89.4
1 1/16	3/4	1 1/16					8 1/16	83.0	8 15/16	81.6	19 1/16	88.0	18 1/16	86.7
		1 1/16					10 1/16	83.7	10 1/16	83.1	22	89.7	22	88.9
1 1/8	3/4 OR 13/16	1 1/16					9 1/16	81.8	9	80.3	18 1/16	86.6	18	85.3
		1 1/16					10 1/16	83.1	10 1/16	82.5	22	89.6	21 1/16	87.8
		1 1/16					10 1/16	82.8	10 1/16	81.9	22	89.3	22	88.4
1 3/16	3/4 OR 13/16	1 1/16					10 7/16	82.7	10 1/16	81.3	21 1/16	87.6	20 1/16	86.2
		1 1/16					11	82.8	11	82.2	22	88.4	22	87.5
1 1/4	7/8	1 1/16					10 1/16	81.3	9 15/16	80.1	20 1/16	86.2	19 1/16	85.0
		1 1/16					11 1/16	82.6	11 1/16	82.1	22 1/16	87.6	22 1/16	87.0
1 5/16	7/8 OR 15/16	1 1/16					9 1/16	80.2	9 1/16	79.1	19 1/16	85.2	19	83.6
		1 1/16					11 1/16	82.3	10 1/16	80.9	22 1/16	87.2	21 1/16	85.6
1 3/8	7/8 OR 15/16	1 1/16					9 1/16	79.2	8 15/16	77.8	19	83.9	18 1/16	82.3
		1 1/16					11	81.3	10 1/16	80.0	22	86.1	21 1/16	84.2
1 7/16	7/8 OR 15/16	1 1/16					9 1/16	78.2	8 15/16	76.8	18 1/16	82.9	17 15/16	81.4
		1 1/16					8 15/16	80.1	10 1/16	78.9	21 1/16	84.9	20 1/16	83.6
1 1/2	15/16 OR 1	1 1/16					9	77.2	8 15/16	75.7	18	81.8	17 1/16	80.2
		1 1/16					10 3/16	79.2	10	78.1	20 1/16	83.9	20	82.6
		1 1/16					11	79.6	11	79.1	22	84.8	22	84.0
1 9/16	15/16 OR 1	1 1/16									20	82.8	19 1/16	81.3
		1 1/16									22 1/16	84.7	22	83.4
1 5/8	1 1/16	1 1/16									19 1/16	81.9	18 3/16	80.3
		1 1/16									19 1/16	81.7	21 1/16	82.5
1 11/16	1 1/16 OR 1 1/8	1 1/16									19	80.6	18 1/16	79.2
		1 1/16									21 1/16	82.9	21	81.5
		1 1/16									24	84.3	23 1/16	83.2
1 3/4	1 1/16 OR 1 1/8	1 1/16									18 1/16	78.8	18	76.4
		1 1/16									21	81.6	20 1/16	80.6
		1 1/16									23 1/16	83.7	23	82.4

The representative character of the club membership is indicated by the fact that 70 office and factory departments were represented on the excursion, from the executive department of the company to the specialized departments of the Schenectady works organization.

THE BUSINESS of the Hughson Steam Specialty Co., which has manufactured the John Davis Co. Eclipse line of steam specialties, has been bought by the Illinois Engineering Co., H. H. Hughson, formerly president of the Hughson Steam Specialty Co., continuing as business manager of the Steam Specialty Department of the Illinois Engineering Co.

AMONG THE MOST VALUABLE services that the Government makes available to business men are the daily "Commerce Reports," a Government publication issued by the Department of Commerce, which gives a daily summary of market conditions and prices in different lines of industry in the world's markets, contains notices of current changes in the tariffs, and the trade-mark laws of foreign countries; gives direct cable information from American consuls and attaches, a daily list of foreign "Trade Opportunities," and complete annual reviews of the trade and industries in every country in the world. Such service naturally cannot be rendered gratis, as the expense is very great, but for the small sum of $2.50 a year, the reports are delivered daily at any address by mail.

The record contains also daily report of what the United States Government wishes to buy or construct, hence it opens up opportunities for a vast amount of trade at home and abroad, in addition to the information on the condition of the markets and the prices current.

The daily "Commerce Reports" can be secured for one year by sending the subscription price, $2.50, with money order or check, to the Superintendent of Documents, Washington, D. C. Postage stamps and mutilated currency cannot be accepted.

GEORGE E. HUMPHREY, for several years chief engineer of the B. & R. Rubber Co., at North Brookfield, Mass., has accepted the position of chief engineer at the Lancaster Mills at Clinton, Mass. The power plant at the Lancaster Mills includes 17 large high pressure boilers carrying 180 lb. steam pressure and having 2 large economizers. There are 2 cross-compound C. & G. Cooper Corliss engines, one 28 by 56 by 60 and one 32 by 64 by 60, each having an independent surface condenser. Besides developing about 5000 electrical horsepower, they buy from the Conn. River Power Co. about 3000 hp. more.

Books and Catalogs

THERMODYNAMIC TABLES AND DIAGRAMS, by Lucke-Flather; New York, 1915; 238 pages, 87 tables and 82 charts; first edition. Price, $1.50.

This little volume, practically a handbook of thermodynamic tables and diagrams, taken from Engineering Thermodynamics, by C. E. Lucke, Ph. D., ought to be of considerable value to students of engineering as well as practicing engineers or others who may have occasion to undertake thermodynamic computations.

The book is divided into 2 parts, the first of which contains the numerous tables covering almost the entire field of heat engineering; Part II is devoted to diagrams together with 11 pages of explanatory matter relative to the construction and use of the diagrams.

HOW TO MAKE A TRANSFORMER FOR LOW PRESSURES, by F. E. Austin; 14 pages, 4 illustrations. Price, 25 cents.

Students, amateur electricians and others interested in the subject will find much valuable information in this booklet relative to the construction of a small transformer capable of operating on 110-v., 60-cycle circuits and delivering a variety of low secondary voltages. By the aid of the directions contained herein anyone may easily and at a low cost construct a transformer such as specified.

This book is obtainable from the Engineering Education Extension, Lock Box 41, Hanover, N. H.

FOXBORO INSTRUMENTS Bulletin 96, issued by The Industrial Instrument Co., Foxboro, Mass., gives brief descriptions of Foxboro recording gages, orifice meters, siphon gages, recording thermometers and hygrometers, indicating electric pyrometers, tachometers, etc.

IN A 20-PAGE BOOKLET the Betson Plastic Fire Brick Co., of Rome, N. Y., tells how to construct a solid, gas-tight, one-piece boiler furnace lining, including front arch, side walls, combustion chamber, rear arch and bridge wall, from the plastic refractory material which that company supplies. Without using special forms or tools, a one-piece, leakless back arch can be obtained, also door arches suitably shaped for the easy

placing of coal on all parts of the grate. The book gives directions for the testing of boiler settings for air leaks, and for the immediate repair, without shutdown, of cracks and holes, to preserve the life of ordinary brick linings to the time when they can be replaced. Illustrations and diagrams show the one-piece lining as applied to the several types of boilers in general use. Copies of this book will be sent on request to those concerned with the management of boilers.

PLATT IRON WORKS, of Dayton, O., has recently issued Bulletin 762, on double suction centrifugal pumps; also, Bulletin 755, on Platt high lift and turbine pumps for high heads, water works, boiler feed, mine and similar service.

FROM McCORD MFG. CO., Detroit, Mich., we have received a new booklet with illustrations showing the construction and operation of the McCord force feed lubricator.

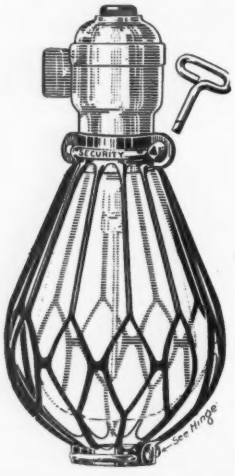
CONSTANT CURRENT TRANSFORMERS for Mazda street lighting systems are the subject of Bulletin Y-685, just issued by General Electric Co.

A 20-PAGE BOOKLET recently issued by The Wm. Powell Co., of Cincinnati, illustrates a complete line of boiler room valves.

THE WESTINGHOUSE Electric & Mfg. Co., has reprinted the paper read by W. M. Dann and H. H. Rudd before the Society of Mechanical, Electrical and Steam Engineers, Toledo, Ohio, June 17. The paper is on the subject of "The Use of Current-Limiting Reactors," covering the advantages to be gained, protection to apparatus and service, the location of the reactors, amount of reactance, cost, etc.

Trade Notes

A NOVELTY in design and construction is shown in the "Security" lamp guards manufactured by the Flexible Steel Lacing Co., of Chicago. The guard is formed of 2 shells of expanded steel, hinging together at their base. It obstructs the light in a minimum degree, combining light weight with strength, and in



addition to guarding against breakage, a special key locking device efficiently prevents tampering with, or theft of the lamp. Dealers will be interested to know that it is packed nested, a dozen guards to the carton, and consequently occupies a minimum space for shipping or in the store room.

YARNALL-WARING CO., of Philadelphia, Pa., has compiled a list of 80 concerns using Simplex Seatless blowoff valves, giving the number used by each company, the total being 2202 valves. The list shows that concerns in every large city of the country use Simplex valves which gives an opportunity for all engineers to see them in operation. A list will be mailed upon request to anybody interested.

THE J. D. CALDWELL CO., of Butte, Mont., and Oregon Bldg., Portland, Ore., will hereafter represent the Nelson Valve Co., Philadelphia, manufacturers of bronze, iron and steel valves, gate, globe, angle and check valves.

PRACTICAL ENGINEER
Trade-mark, Reg. U. S. Pat. Off.

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537 S. Dearborn Street

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Position Wanted

POSITION WANTED—As Meter Foreman and Power Salesman. Have had nine years practical and technical experience. Thoroughly familiar with the requirements of the Public Service Commission of Pennsylvania. Address Practical Engineer, Box 405, Chicago, Ill. 9-15-2

POSITION WANTED—By man of good habits. Age 30. Technical education. 12 years machinist and electrician, 2 years engineer, 2 years salesman. What have you? Address Practical Engineer, Box 401, Chicago, Ill. 8-15-2

POSITION WANTED—Chief Engineer of wide experience solicits correspondence with large manufacturing concern in view of locating with same. Have U. S. Marine Engineer's License for Chief Engineer; License for Pittsburgh, Pa. First-class for State of Ohio. Am a teetotaller and require the same of my help as far as possible. Can furnish best of references from present employers. Address Box 403, Practical Engineer, Chicago, Ill. 9-1-1

POSITION WANTED—By man 26 years of age. Have had 28 months' experience as general man around stationary power plant, and 2 yrs. running traction engine; also hold fireman's license. Reference will be furnished to any one wishing to correspond with me concerning a position. Address Geo. M. Bucey, 1614 O St., Lincoln, Nebr. 9-15-1

POSITION WANTED—By engineer in medium sized power plant or assistant in large one. Have third class Ohio license. 5 yrs. experience with both Horizontal Tubular and Water Tube Boilers and steam engines. Some experience with electricity. Good habits. Sober. 26 yrs. old. Good reference furnished if necessary. Address Emmett R. Ralston, Lock Box 212, Chesire, Ohio. 9-15-1

Help Wanted

WANTED—Resident subscription agents in the following cities: Atlanta, Ga.; Cincinnati and Columbus, Ohio; Kansas City, Mo.; Los Angeles, Calif.; Louisville, Ky.; Newark, N. J.; New Orleans, La.; Portland, Ore.; St. Louis, Mo.; San Francisco, Calif.; Washington, D. C. This is an excellent chance for a hustler, who is familiar with power plant conditions, to turn his spare time into dollars. To such a one we offer a Real Opportunity. Write Subscription Department, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

FREE ENGINEER BOOKS and power plant tools and specialties for securing new subscribers to Practical Engineer. A dandy chance for the engineer with a little spare time to get some fine premiums. Send for free descriptive circular and terms. Address Practical Engineer, Subscription Department, Chicago, Ill.

REPRESENTATIVES to cover territory more thoroughly. Boiler-room necessities; liberal commissions; old-established house. Apply by letter. H. F. Maurel, 534 West 22nd St., New York City. 7-15-6

Wanted

WANTED—Good live practical man who is looking for a location to install an electric lighting plant in good North Dakota town of 500 population. Situated in one of best farming communities in the Mouse River Loop section with all lines of business represented. For particulars address The American, Antler, N.D.

WANTED—Agents handling engine and boiler-room specialties in every section for side line paying large commissions. Give experience, line carried, and territory covered. Address Practical Engineer, Box 381, Chicago, Ill. tf.

WANTED—Agents on commission to sell our Shaking Grates. We will install grates on trial or put in on test at our expense with any grate made. Address Armstrong Mfg. Company, Springfield, Ohio. tf.

WANTED—Experienced men to demonstrate and take orders for Pulle-Y-Grasp belt dressing during spare hours. Send for free sample and part. Cardinal Mfg. Co., Cleveland, Ohio. tf.

CHEMIST with experience as efficiency engineer in boiler house wanted. Good education and experience needed. State fully age, married or single and salary expected. Address Practical Engineer, Box 402, Chicago, Ill. 8-15-6

WANTED—Agents on commission to sell a steam plant necessity. A revolution of its kind. Attractive commission. Address Practical Engineer, Box 406, Chicago, Ill. 9-15-1

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FOR SALE—One 20 Ton Ice Plant and Coal business. Factory in operation, fully equipped and in good shape, cheap fuel, deep wells. Good established trade. City's population about 90,000, unlimited opportunities for expansion of business. Will sell at a bargain if taken at once. Would consider party who could invest $6000 to $8000 to increase output and take position with firm. For full information, address George Brown, 221 Harriet St., Evansville, Ind.

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